Atmosphere-Ocean Science:
Science de l'atmosphère et de l'océan :

IMPACTS AND INNOVATION
IMPACTS ET INNOVATION

CANADIAN METEOROLOGICAL AND OCEANOGRAPHIC SOCIETY
SOCIÉTÉ CANADIENNE DE MÉTÉOROLOGIE ET D'OCÉANOGRAPHIE

37th Congress
2-5 June 2003
Crowne Plaza Hotel
Ottawa

37e Congrès
2-5 juin 2003
Hôtel Crowne Plaza
Ottawa

www.cmos.ca www.scmo.ca

Société canadienne de météorologie et d'océanographie
Canadian Meteorological and Oceanographic Society

37th CMOS Congress / 37e Congrès de la SCMO

Ottawa 2003

June 2-5, 2003 / 2–5 juin 2003

Atmosphere-Ocean Science: Impacts and Innovation

Science de l'atmosphère et de l'océan : Impacts et innovation

Co-Editors / Co-Éditeurs:
Mario Ouellet and Martha Anderson

Programme et résumés
Program and Abstracts

www.cmos.ca / www.scmo.ca

ISBN 0-9732812-0-0

Bob Chiarelli
Mayor / Maire

CMOS Ottawa Congress
Crowne Plaza
Ottawa, Ontario
June 2-5, 2003

Dear Delegate:

On behalf of City Council and the people of Ottawa, it is my great pleasure to extend a personal welcome to everyone who has joined us in Canada's Capital for the CMOS Ottawa Congress.

It is an honour for our city to host delegates from across Canada who have gathered here for this special event in our community. I thank you for choosing Ottawa as the site of your 2003 event, and commend the host committee for all the work that has been devoted to the organization of this gathering in our city.

Ottawa, Canada's leading centre for high technology research and development, is a place that all Canadians visiting from out of town can truly call their second home. We welcome our visitors with a unique brand of friendly Canadian hospitality. Ottawa is a clean, green and safe city that offers the joie de vivre and local charm of a small town while providing all the attractions and excitement of a modern, cosmopolitan centre -- and a national capital. Our hotels, restaurants, shops and meeting places always go out of their way to make every gathering in our city a stunning success.

During your stay in the nation's capital, I invite you to explore the numerous attractions and amenities we have to offer -- our parks, monuments and museums, our waterways and market places, and most of all, the warmth of our people. May your time with us be a pleasant one, and this meeting, a productive and rewarding experience for all.

Sincerely,

Bob Chiarelli
Mayor, City of Ottawa

Congrès de la SCMO à Ottawa
Crowne Plaza
Ottawa (Ontario)
du 2 à 5 juin, 2003

Monsieur, Madame:

Au nom du Conseil municipal et de la population d'Ottawa, il me fait grand plaisir de souhaiter la bienvenue à ceux et celles qui sont des nôtres dans la capitale du Canada à l'occasion du Congrès de la SCMO à Ottawa.

C'est un honneur pour notre ville d'être l'hôte des délégués d'à travers le Canada, qui se sont rassemblés ici pour cet événement spécial. Je vous remercie d'avoir choisi Ottawa pour votre réunion de 2003 et félicite l'Association pour tout le travail d'organisation de cette réunion dans notre ville.

Ottawa, premier centre canadien de la recherche et du développement dans le domaine de la technologie de pointe, est véritablement le second chez-soi des Canadiennes et des Canadiens. Nous offrons à nos visiteurs une forme d'hospitalité unique et authentiquement canadienne. Ottawa est une ville verte, propre et sécuritaire où convergent la joie de vivre et le charme d'une petite agglomération et les attractions et la vitalité d'une ville moderne cosmopolite -- sans oublier qu'elle est la capitale nationale. Le personnel des hôtels, des restaurants, des boutiques et des lieux de rencontre veille invariablement à ce que chaque assemblée connaisse un succès retentissant.

Je vous invite à découvrir les nombreux points d'intérêt et attractions que compte notre ville, ses parcs, ses monuments, ses musées, ses cours d'eau et ses marchés, et à goûter la cordialité de ses gens. J'espère que votre séjour parmi nous sera agréable et que cette réunion sera productive et enrichissante pour tous les participants.

Le maire d'Ottawa,

Bob Chiarelli

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A Word 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", the Weather Research House/CMOS/NSERC graduate student supplementary scholarship, undergraduate scholarships and several prizes.

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 sciences and education across Canada.

Events over the past year include a surge in private sector activities and a proposed doubling of our financial management service contract with the Canadian Association of Physicists which has led to the decision of assuming these affairs on our own. After June 30, 2003, the new CMOS address will be:

Canadian Meteorological and Oceanographic Society
PO Box 3211
Station D
Ottawa ON K1P 6H7

Detailed information on CMOS can be found at www.cmos.ca

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'agrémentation 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 au congrès annuel, une bourse de voyage à un enseignant pour l'atelier "Project Atmosphere" de I'AMS/NOAA, la bourse de troisième cycle "Weather Research House/SCMO/CRSNG", des bourse aux étudiants sous gradués et plusieurs prix.

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 de recherches originales. La SCMO a aussi une page d'accueil sur son site WEB où on trouve de l'information générale sur la SCMO et ses activités, ainsi que sur la science et l'enseignement de la météorologie et de l'océanographie au Canada.

Les événements marquants de l'année passée incluent une recrudescence des activités du secteur privé et la proposition de doubler les frais de notre entente d'administration financière par l'Association des physiciens du Canada. Cette augmentation imprévue des frais a contribué à la décision du Comité exécutif d'acheter un logiciel de banque de données moderne et d'assumer nos services administratifs nous-mêmes.

Après le 30 juin 2003, la nouvelle adresse de la SCMO sera:

Société canadienne de météorologie et d'océanographie.
C.P. 3211
Station D
Ottawa, ON
K1P 6H7

On trouvera plus d'information sur la SCMO à http://www.scmo.ca

A Word from our President

Un mot de notre président

On behalf of the CMOS National Executive, I'd like to welcome you to the 37th annual CMOS Congress. The annual Congress is an important time for the sciences of meteorology and oceanography and related disciplines; it is a time to hear new ideas, share our knowledge and get inspired. It is also a time to renew old friendships and make new acquaintances.

As I finish my term as President as CMOS, I am proud of this organization and its role in bringing together professionals in the atmospheric and oceanic sciences. I feel we have accomplished a great deal this year in encouraging interactions between the Meteorological Service of Canada and the private sector companies who deliver weather services to Canadians. We have also contributed to the debate about the Kyoto Accord, and climate change by producing a policy statement outlining the official position of CMOS on this important and ongoing issue. We have made the first steps in significant advancement of services to members by commissioning a new database to track membership, Congress and publication information. Membership renewal was a focus for Council this year, with several innovative and progressive measures taken to make renewal easier and more enticing. And finally, I am pleased with our work towards our Vision Paper, which will provide the blueprint for a strong future for CMOS.

On behalf of the CMOS Executive, I'd like to thank the Ottawa Centre and the Local Arrangements Committee headed by Bruce Ramsay for hosting this outstanding event.

Au nom de l'exécutif national de la SCMO, il me fait grand plaisir de vous souhaiter la bienvenue au 37ième congrès annuel de la SCMO. Le congrès annuel est un temps privilégié pour les sciences de la météorologie, de l'océanographie et des disciplines connexes ; il nous fournit l'occasion d'accueillir de nouvelles idées, de partager des connaissances et d'y trouver une source d'inspiration. C'est aussi l'occasion de renouveler de vieilles amitiés et d'établir de nouvelles relations.

Au terme de mon mandat à la présidence de la SCMO, je suis fier de cette organisation et de son rôle clé de rassembler des professionnels des sciences atmosphériques et océaniques. Je sens que nous avons progressé de façon importante cette année au niveau des interactions fructueuses entre le Service météorologique du Canada et les entreprises du secteur privé qui dispensent des services météorologiques aux Canadiens. Nous avons contribué au débat autour du protocole de Kyoto et de la question des changements climatiques en produisant un document qui expose la position officielle de la SCMO eu égard à ce sujet d'actualité. Nous avons posé les jalons d'une amélioration des services aux membres en faisant établir une nouvelle base de données pour optimiser la coordination des informations relatives aux membres, au congrès et à nos publications. Cette année, le conseil a concentré ses efforts sur le renouvellement des adhésions, en prenant diverses mesures innovatrices et plus efficaces susceptibles de faciliter ce renouvellement et de le rendre plus alléchant. Et, finalement, nous avons initié la rédaction de notre mémoire sur une vision renforcée de l'avenir de la SCMO.

Au nom du conseil d'administration de la SCMO, j'aimerais remercier le centre d'Ottawa ainsi que le comité organisateur local dirigé par Bruce Ramsay d'être l'hôte de cet événement exceptionnel.

Le président de la SCMO

Ron Bianchi
CMOS President

A Word from the Chair of the Science Program Committee

Un mot du président du comité scientifique

Welcome to the 37th CMOS Congress in Ottawa! As you will see from this very full program book we had an excellent response to our call for papers this year. The Science Program Committee and the convenors have done our best to include as many talks and posters as possible in the program, and to minimise conflicts.

Our theme, **Atmosphere-Ocean Science: Impacts and Innovation,** captures the essence of our work, striving to make a difference and improve the collective knowledge of our sciences, for the betterment of society. We also need to make society more aware of the value of our services. New knowledge in the atmospheric and oceanic sciences can have an impact on Canadians in many ways. Improved weather, and seasonal climate, forecasts are important for many Canadian industries and for the health and safety of the general public. An improved understanding of physical, chemical and biological processes in the oceans will help the fishing and other marine industries better understand their resource and environment. Knowledge of climate change and the potential impacts it may have on Canadians in the coming decades is essential for policy-makers, businesses and citizens as they plan for the future.

I wish you a productive week at our Congress, and hope it leaves you inspired to work towards new innovations in atmosphere-ocean science.

Peter Taylor
Chair, Science Program Committee

Je vous souhaite la plus cordiale bienvenue au 37e Congrès de la SCMO, à Ottawa. Comme vous le constaterez en feuilletant ce cahier, nous avons obtenu une excellente réponse à notre appel de communications scientifiques. Les membres du comité du programme scientifique et les responsables des différentes sessions ont fait de leur mieux pour inscrire au programme autant de communications orales et sur affiches que possible et à minimiser les conflits.

Le thème que nous avons choisi, **Science de l'atmosphère et de l'océan : Impacts et innovation**, reflète parfaitement l'objectif que sous-tendent nos efforts : faire évoluer et progresser nos disciplines scientifiques pour le mieux-être de la société. Il nous faut également faire en sorte que la société soit mieux informée de la valeur des services que nous rendons. Les nouvelles connaissances en sciences atmosphérique et océanique se répercutent de multiples façons sur les Canadiens. De meilleures prévisions du temps et du climat saisonnier prennent une grande importance pour l'industrie canadienne, ainsi que pour la santé et la sécurité du public. Une meilleure compréhension des processus physiques, chimiques et biologiques au sein des océans aidera les pêcheries et les autres industries marines à mieux comprendre leur ressource et leur environnement. Une compréhension du phénomène du changement climatique et de ses incidences sur les Canadiens au cours des prochaines décennies sera essentielle pour les décideurs, les gens d'affaires et tous ceux et celles qui ont à planifier l'avenir.

Je vous souhaite de vivre une semaine productive qui, je l'espère, saura vous inspirer à poursuivre vos travaux en science de l'atmosphère-océan de façon innovatrice.

Le président du comité scientifique,
Peter Taylor

A Word from the Chair of the Local Arrangements Committee

Un mot du président du comité organisateur local

As Chair of the Ottawa Centre Local Arrangements Committee, I would like to extend a warm welcome to the participants in the 2003 CMOS Congress. We are confident that you will find this year's program to be first-rate. The huge number of abstract submissions we received has allowed us to bring a great deal of interesting material from the atmospheric and oceanic sciences together under the theme "Impacts and Innovation". We hope you will leave Ottawa having made new contacts and taking with you inspirations for new innovations in your field of work.

I'd like to give special thanks to Dr. Peter Taylor of York University and his Science Program Committee for developing the program for this year's Congress. As well, I'd like to thank my Local Arrangements Committee, whose hard work over one and a half years has made it all possible. And of course, special thanks goes out to everyone who submitted their work for a session or poster.

This is a beautiful time of year in Ottawa and I do hope you will get out and enjoy the nation's capital, as well as the terrific scientific program we have planned for the Congress.

Bruce Ramsay
Chair
Ottawa Local Arrangements Committee

En ma qualité de président du comité organisateur local du Centre d'Ottawa, il me fait plaisir d'accueillir tous les participants au congrès 2003 de la SCMO. Je suis confiant que vous apprécierez la très grande valeur du programme de cette année. Le fait que nous ayons reçu un si grand nombre de résumés de communications scientifiques nous a permis de regrouper sous le thème porteur «Impacts et Innovation» une grande quantité de matériel intéressant en sciences météorologiques et océaniques. Je formule l'espoir qu'à votre départ d'Ottawa vous aurez établi de nombreux et fructueux contacts et aurez été inspirés pour innover dans vos domaines respectifs.

J'aimerais remercier tout particulièrement Peter Taylor de l'Université York et son comité pour avoir élaboré le programme scientifique du congrès de cette année. De même, je me dois de remercier mon comité organisateur local qui a besogné pendant plus de un an et demi afin de parvenir à ce magnifique résultat. Un grand merci finalement à tous ceux et celles qui ont présenté des travaux scientifiques lors des sessions orales et sur affiches.

Le temps est magnifique à Ottawa en cette période de l'année et j'espère que vous profiterez autant des attraits de la capitale nationale que du programme scientifique hors pair que nous avons planifié pour ce congrès.

Bruce Ramsay
Président
Comité organisateur local d'Ottawa

Local Arrangements Committee / Comité organisateur local

Chair / Président - Bruce Ramsay, EC
Audio Visual Equipment / Technologie, audio-visuel – Brian Beamish, EC
Communications / Communications – Martha Anderson, DFO
Exhibits / Exposants – Guy Stogaitis, EC
Oscar Koren, retired
Facilities / Locaux – Bernadette Flemming, EC
Finances / Finances - John Falkingham, EC
Chair, Ottawa Centre / Président, Centre d'Ottawa – Wayne Richardson, NRCan
Registration / Inscription – Serge Nadon, EC
Sponsors / Commandites – Jim Helbig, DFO
Teacher's Day / Journée des enseignants – Dawn Conway, CFCAS
Technical Tours and Tourism / Visites à caractère technique et tourisme – Leslie Malone, EC
Translation / Traduction – Yvon Bernier, retired
Web Site / Site web – Bob Jones, retired

Science Program Committee / Comité du programme scientifique

Chair / Président – Peter Taylor, York University
Roger De Abreu, EC
Charles Lin, McGill University
Savi Narayanan, DFO
Bruce Ramsay, EC
John D. Reid, Consultant
Richard Stoddart, CNC/SCOR
Geoff Strong, Consultant
Paris Vachon, NRCan

Bruce and Peter would like to thank the many volunteers that helped the Local Arrangements Committee during the Congress week, and the session chairs who organized and hosted the science sessions. Special thanks to Albert Said, EC, for creating and printing Congress signage, and Mario Ouellet, EC, who prepared the abstract section of this book.

We'd also like to recognize our sponsors for the printing of this book, Fisheries and Oceans Canada Science Sector, and Environment Canada Meteorological Service of Canada, and Zsuzsanna Liko Visual Communication Inc. for the book cover.

Environment Canada Environnement Canada

Fisheries and Oceans Canada Pêches et Océans Canada

Bruce et Peter aimeraient remercier les nombreux bénévoles qui one fournit leur aide au comité organisateur local Durant la semaine du congrès, ainsi que les responsables de sessions qui onr organisé et présidé les sessions scientifiques. Un merci particulier à Albert Said d'Environnement Canada pour avoir créé et imprimé les affiches pour le congrès, et à Mario Ouellet, également d'Environnement Canada, pour avoir préparé la section de ce cahier portant sur les résumés de communications scientifiques.

Nous aimerions également souligner l'appui de nos commanditaires dans l'impression de ce cahier: Pêches et Océans Canada(secteur Sciences) et le Service météorologique du Canada d'Environnement Canada, et Zsusanna Liko Visual Communications Inc. pour le dessin de la couverture du programme.

The Organizers

Les organisateurs

Information and Social Events

REGISTRATION AND INFORMATION DESK

The registration desk is located in the Crowne Plaza Hotel lower lobby and will be open during the following periods:

Sunday June 1 from 15:00 to 20:00.
Monday June 2 from 07:30 to 18:00.
Tuesday June 3 from 07:30 to 18:00.
Wednesday June 4 from 07:30 to 18:00.
Thursday June 5 from 07:30 to 14:00.

General Congress information will be available each day at the registration desk. Extra tickets for social events can be purchased at the registration desk.

CONGRESS ROOMS

The following meeting rooms in the Crown Plaza Hotel will be used during the Congress:

Penthouse Level **–** Panorama and Pinnacle Rooms – for science sessions, poster displays and the Icebreaker.

Conference Level (above main lobby) – Chaudière, Joliet, Frontenac and Richelieu Rooms – for science sessions and meetings.

Lower Level (below main lobby) – Victoria Room for Internet Café; Ballroom A for commercial exhibits; Ballrooms B & C for plenary sessions, the Awards Luncheon and Banquet.

TOURIST INFORMATION

The Ottawa Tourism and Convention Authority will have brochures and pamphlets on attractions in the National Capital Region available during the CMOS Congress, and will provide a staffed tourist information desk in the lower lobby at convenient times, June 1 to 3. Information on Ottawa's attractions and restaurants can also be obtained from the hotel concierge desk in the main lobby.

COMPUTER SERVICES

For Internet access and other computer needs of the participants, eight PC-type computers will be available in the Victoria Room on the lower level as follows:

Monday June 2 from 12:00 to 18:00.
Tuesday June 3 from 07:30 to 18:00.
Wednesday June 4 from 07:30 to 18:00.
Thursday June 5 from 07:30 to 13:30.

A CD-ROM burning service for PC-type computers will be available for PowerPoint presentations with the aid of an assistant during these hours in the Victoria Room.

MESSAGE BOARD

A message board will be available in the Victoria Room, to allow Congress attendees to receive messages from other attendees or their home or office.

POSTER SESSIONS

Science posters will be on display in three groupings, for one day each, in the lobby on the penthouse Level. Presenters will be available to discuss their work at the following times:

Poster Group A – Tuesday June 3, 17:30 to 18:30
Poster Group B – Wednesday June 4, 17:30 to 18:30
Poster Group C – Thursday June 5, 12:30 to 13:30

Coffee will be served in the poster area at morning and afternoon coffee breaks, and a cash bar will be available during the above times.

TEACHER'S DAY
English and French elementary and high school teachers of science, geography and related subjects in the National Capital Region have been invited to a special session on Monday June 2 from 10:00 to 16:00. Their program will include presentations, discussions and demonstrations related to the teaching of weather dynamics, systems and climate. David Phillips, Senior Climatologist of the Meteorological Service of Canada will be a special guest.

CSAM and CGU
For the 2003 CMOS Congress, we welcome the Canadian Society of Agrometeorologists and the Canadian Geophysical Union. Members of CSAM and CGU were permitted membership rates for 2003 CMOS Congress registration, and allotted their own dedicated sessions.

ICEBREAKER
Our icebreaker sponsor, Campbell Scientific Inc., invites all participants for food and refreshments at 18:00 Monday June 2 on the Crowne Plaza penthouse level, overlooking the Ottawa River (Bar opens 17:30). Each participant's registration package includes an ICEBREAKER ticket which can be exchanged for one free drink at the bar. A cash-bar service will be provided thereafter. Enjoy the music of Ice Jammers, a local reggae band whose members include a few Canadian Ice Service staff. Extra tickets can be purchased at the Registration Desk.

AWARDS LUNCHEON
The Awards Luncheon will be served in Ballrooms B & C on Tuesday June 3 from 12:00 to 13:45. The following honours will be announced during the lunch: the J.-P. Tully Medal and the Rube Hornstein Medal presented by CMOS President Ron Bianchi, and the Patterson Medal and the Jim Bruce Acheivement Award presented by Meteorological Service of Canada Assistant Deputy Minister Marc Denis Everell. The students receiving the CMOS Travel Bursaries will be announced. Extra tickets can be purchased at the Registration Desk.

BANQUET
The annual Congress Banquet will be held in Ballrooms B & C on Wednesday June 4. Cocktails will begin at 18:30 and dinner will be served at 19:30. Various honours will be presented at the end of dinner, including: the President's Prize, the Andrew Thomson Prize, three Prizes in Applied Oceanography, the Tertia M.C. Hughes Memorial Graduate Student Prize, several CMOS Citations and the CMOS Weather Research House Scholarship. The dinner will be followed by an animated evening with "The Kelvin Band" from MSC's Canadian Meteorological Centre (CMC). Extra tickets can be purchased at the Registration Desk.

BEST STUDENT POSTER PRIZE
The Campbell Scientific Best Student Poster Prize will be presented on Thursday June 5 between 12:30 and 13:30 in the penthouse lobby, during the poster viewing session.

TECHNICAL TOURS
Two tours of local scientific facilities are planned during the Congress. Space is limited, and free registration will be on a first come - first served basis. Early registration is encouraged (see the CMOS web page), but sign up sheets and more information will be available at the registration desk as well.
- Wednesday, June 4, 13:30 to 16:30 - tour the National Research Council 9 metre wind tunnel and the Flight Research Laboratory's aircraft hangar at the Uplands Research Complex. Bus departs from the hotel at 13:30.
- Thursday, June 5, 09:00 to 11:30 - tour the David Florida Laboratory of the Canadian Space Agency. Bus departs from the hotel at 09:00.

Information and Social Events

ART SHOW

Throughout the Hotel facilities used for the Congress, Phil "The Forecaster" Chadwick of Toronto will be displaying works of his art reflecting the meteorology and oceanography themes of the Congress. The paintings will be changed daily so that registrants can get a new, refreshing view of our environment through Phil's eyes.

KEN HARE MEMORIAL LECTURE

Ken Hare was involved in academic and public policy aspects of natural and artificial “climate change” before that concept became current. At McGill University, among many other things, (including the founding of the Department of Meteorology), he founded and built up the McGill Subarctic Research Laboratory in Schefferville, northern Quebec, and was a founder of the McGill Axel Heiberg Expeditions. The former was a university-run weather station, which was a base for training and research by resident students for twenty years. It continues today on the McGill Subarctic Research Station. The second, among many other things, initiated glacier research at 80 degrees North, a latitude which is of great interest nowadays as a part of the world where global warming is predicted to be most marked. Research on these glaciers continues today. In his later years, Ken was a two-term Chancellor of Trent University, where through teaching and example, he continued to influence climate research. Through his life, he took an active interest in the translation of the results of academic research into public policy at the provincial, federal and international levels.

Join us for a tribute to Dr. Ken Hare during the Climate I session, Monday June 2 at 12:00 with the invited lecture by Peter Adams, MP (Peterborough) entitled **Ken Hare and Climate Research.**

Renseignements et événements sociaux

KIOSQUE D'INSCRIPTION ET RENSEIGNEMENTS
L'inscription a lieu dans le lobby inférieur de l'hôtel Crowne Plaza durant les périodes suivantes :

dimanche le 1er juin de 15h00 à 20h00
lundi le 2 juin de 7h30 à 18h00
mardi le 3 juin de 7h30 à 18h00
mercredi le 4 juin de 7h30 à 18h00
jeudi le 5 juin de 7h30 à 14h00

Un service d'accueil sera disponible chaque jour au kiosque d'inscription. On peut également s'y procurer des billets d'entrée et des coupons additionnels pour participer aux événements sociaux.

SALLES POUR LE CONGRÈS
Durant le congrès, les salles suivantes seront utilisées :
Niveau Penthouse – les salles Panorama et Pinnacle – pour des sessions scientifiques, les affiches et le cocktail de bienvenue.
Niveau des conférences (un niveau plus haut que le hall d'entrée) – les salles Chaudière, Joliet, Frontenac et Richelieu - pour des sessions scientifiques et des réunions.
Niveau inférieur (un niveau plus bas que le hall d'entrée) – la salle Victoria est le Café Internet; la salle de bal A pour les exposants commerciaux; les salles de bal B & C pour les sessions plénières, le déjeuner des récompenses et le banquet.

RENSEIGNEMENTS TOURISTIQUES
L'Administration du tourisme et de congrès d'Ottawa mettra à la disposition des congressistes des dépliants et feuillets d'information sur les attraits touristiques d'intérêt dans la Région de la Capitale nationale durant le congrès de la SCMO et affectera en plus du personnel à un kiosque d'information touristique dans le lobby inférieur de l'hôtel aux heures d'achalandage du 1er au 3 juin. Il sera également possible d'obtenir de l'information sur les attraits touristiques d'Ottawa au pupitre du portier de l'hôtel dans le hall d'entrée.

SERVICES INFORMATIQUES
Pour l'accès à Internet et d'autres besoins informatiques des participants, huit ordinateurs de type PC seront disponibles à la salle Victoria, au niveau inférieur, aux heures suivantes :

lundi le 2 juin de 12h00 à 18h00
mardi le 3 juin de 7h30 à 18h00
mercredi le 4 juin de 7h30 à 18h00
jeudi le 5 juin de 7h30 à 13h30

Un service de graveur sur CD-ROM avec un ordinateur de type PC pour les présentations Power Point sera disponible avec l'aide d'un assistant aux mêmes heures à la salle Victoria.

BABILLARD
Un babillard sera installé dans la salle Victoria afin de permettre aux congressistes de recevoir des messages d'autres congressistes ou de l'extérieur.

Renseignements et événements sociaux

SESSIONS SUR AFFICHES

Des communications scientifiques sur affiches seront en montre en trois regroupements, chacun d'une durée d'une journée, dans le hall au niveau penthouse. Les présentateurs de ces communications seront à leur affiche pour discuter de leurs travaux aux heures suivantes :
Affiches du groupe A – mardi le 3 juin de 17h30 à 18h30
Affiches du groupe B – mercredi le 4 juin de 17h30 à 18h30
Affiches du groupe C - jeudi le 5 juin de 12h30 à 13h30.
Le café sera servi dans le secteur des affiches lors des pauses-santé de la matinée et de l'après-midi, et un bar payant sera ouvert aux heures ci-haut mentionnées.

JOURNÉE DES ENSEIGNANTS

Les enseignants des écoles primaires de langues française et anglaise spécialisés en science, en géographie ou en des matières connexes ont été invités à participer à une session particulière le lundi 2 juin de 10h00 à 16h00. Leur programme d'activités comprendra des présentations, des échanges et des démonstrations en rapport avec l'enseignement de la météorologie (dynamique et systèmes météo) et de la climatologie. L'invité d'honneur sera Dave Phillips, climatologue principal au Service météorologique canadien.

SCAM ET UGC

Nous souhaitons la bienvenue au congrès 2003 de la SCMO à la Société canadienne d'agrométéorologie ainsi qu'à l'Union géophysique canadienne. Leurs membres ont pu s'inscrire au congrès de la SCMO au même tarif que les membres de la SCMO. On a également prévu des sessions particulières qui leur sont consacrées.

COCKTAIL DE BIENVENUE

Le commanditaire cet événement, Campbell Scientific Inc., invite tous les congressistes à ce cocktail qui se tiendra le lundi 2 juin à 18h00 dans le hall de l'hôtel Crowne Plaza au niveau penthouse, un endroit propice pour fraterniser et admirer la vue sur la rivière des Outaouais. Le bar sera ouvert à compter de 17h30. La pochette d'inscription contient un coupon pour ce cocktail, lequel donne droit à une consommation gratuite au bar. Des consommations additionnelles seront en vente au bar. Un groupe reggae, les «Ice Jammers», dont certains des musiciens sont des employés du Centre canadien des glaces, divertira les participants

DÉJEUNER DES RÉCOMPENSES

Ce repas sera servi dans les salles de bal B&C le mardi 3 juin de midi à 13h45. On y annoncera les lauréats des honneurs suivants : la Médaille J.P. Tully, la Médaille Patterson, la Médaille Rube Hornstein, et le Jim Bruce Acheivement Award. On annoncera également les récipiendaires des bourses de la SCMO aux étudiants congressistes. Il sera possible de se procurer des billets de participation supplémentaires pour ce déjeuner au kiosque d'inscription.

BANQUET

Le Banquet annuel de la Congrès aura lieu dans les salles de bal B&C le mercredi 4 juin. Les apéritifs seront servis à compter de 18h30 et le repas à 19h30. Plusieurs prix seront décernés à la fin du dîner. La soirée dansante qui suivra sera animée par le groupe musical Kelvin, dont les membres sont des employés du Centre météorologique canadien. On peut se procurer des billets supplémentaires pour le banquet au kiosque d'inscription.

LE PRIX POUR LA MEILLEURE AFFICHE D'UN ÉTUDIENT

Le prix Campbell Scientific Inc. pour la meilleure communication sur affiche d'un étudiant ou d'une étudiante sera présenté le jeudi 5 juin entre 12h30 et 13h30 dans le hall au niveau penthouse.

VISITES À CARACTÈRE TECHNIQUE

Des visites à caractère scientifique sont prévues durant le congrès. Elles sont offertes gratuitement par la SCMO, mais puisque l'espace est limité, les premiers à s'inscrire seront les premiers servis. Nous encourageons donc les personnes intéressées à s'inscrire le plus tôt possible (voir la page Web de la SCMO). Des feuilles d'inscription seront également mises à la disposition des congressistes ai kiosque d'inscription.

- mercredi le 4 juin, de 13h30 à 16h30 – visite des installations du Conseil national de recherches : le Laboratoire de recherche en vol et la Soufflerie de 9m sur le complexe de recherche d'Uplands. L'autobus nolisé partira de l'hôtel à 13h30;
- jeudi le 5 juin, de 9h00 à 11h30 – visite du Laboratoire David Florida de l'Agence spatiale canadienne. L'autobus nolisé partira de l'hôtel à 9h00.

EXPOSITION D'ART

Durant toute la durée du congrès, les œuvres de Phil Chadwick, dit «le Prévisionniste», seront en montre ça et là dans les divers locaux du congrès. Ces œuvres reflètent divers aspects météorologiques et océanographiques du thème du congrès de cette année. Afin que les congressistes puissent s'imprégner des visions environnementales de l'artiste, les œuvres seront changées à chaque jour.

HOMMAGE À KEN HARE

Bien avant que le concept de «changement climatique» devienne un sujet populaire, Ken Hare s'intéressait aux aspects académiques et de la politique publique du changement climatique naturel et artificiel. Parmi ses nombreuses réalisations à l'Université McGill, dont l'établissement du Département de météorologie, il a fondé le Laboratoire de recherche sub-arctique de McGill, qui est situé à Schefferville, au nord du Québec. Il est aussi un des membres fondateurs des Expéditions McGill Axel Heiberg. Le laboratoire de recherche consistait en une station météorologique, opérée par l'université, qui servait de base pour le perfectionnement des étudiants et la recherche, pendant vingt ans. Le laboratoire existe toujours et fait partie de la station de recherche sub-arctique de McGill. Pour leur part, les expéditions ont permis, entre autres, d'initier des recherches sur les glaciers à une latitude de 80 degrés nord, un lieu qui suscite aujourd'hui beaucoup d'intérêt parce que les prévisions indiquent que l'Arctique sera une région des plus touchées par le réchauffement global. Encore de nos jours, la recherche sur ces glaciers continue. Plus tard dans sa carrière, Ken a occupé le poste de Chancelier de l'Université Trent, pour une période de deux mandats. Là, il a continué à influencer la recherche sur le climat par l'enseignement et par l'exemple. Toute sa vie, il a su montrer son intérêt à traduire les résultats de la recherche académique afin de les appliquer dans la politique publique aux niveaux provincial, fédéral et international.

Joignez-vous à nous pour rendre hommage à Ken Hare à midi, le lundi 2 juin, durant la session Climat 1, alors que le conférencier invité, Peter Adams, député de Peterborough, prononcera une allocution sur **Ken Hare and Climate Research**.

Plenary Speakers

Conférenciers des plénières

June 2 / 2 juin
08:40
Opening Speaker / Présentation d'ouverture:
The Honourable David Anderson, Minister of the Environment / L'honorable David Anderson ministre fédéral de l'Environnement

09:00
Tom Karl, National Climate Data Centre, USA - ***Monitoring Climate Change and Variations: Progress and Challenges***

09:30
Roberta M. Johnson, University Corporation for Atmospheric Research, USA - ***Sharing Science with the Public at a National Research Laboratory***

June 3 / 3 juin
08:30
William Bird, Health Forecast Unit, Meteorological Office, UK - ***Forecasting the Nation's Health - the UK Met Office Experience in Predicting Daily Workload in the British Health System***

09:00
Wendy Watson-Wright, DFO - ***Climate Change Impacts and Adaptation - DFO's Response to the Challenge***

09:30
Kimberley Strong, Department of Physics, University of Toronto - ***Measurements of Chemical Constituents in the Stratosphere from Balloon-borne and Ground-based Instruments***

June 4 / 4 juin
08:30
Harold Brooks, NOAA National Severe Storms Laboratory, USA - ***Evaluation of Forecasts of High Impact Weather***

09:00
Pierre Dubreuil, MSC - ***Air Quality Prediction: An Overview of MSC's Program***

09:30
Donald Perovich, USACE Engineering Research and Development Centre, USA - ***SHEBA: The Surface Heat Budget of the Arctic Ocean***

June 5 / 5 juin
08:30
Bjarni Tryggvason, Canadian Astronaut Program - ***Space Technologies, Global Monitoring of the Natural Environments: Canada's Role***

09:00
Ming-ko Woo, School of Geography and Geology, McMaster University - ***Water in a Cold Climate: the Mackenzie GEWEX Story***.

09:30
President's Prize Winner Lecture - TBA

Meetings

Réunions

TIME / HEURE	MEETINGS / RÉUNIONS	LEAD	ROOM / SALLE
Sunday, June 1 / dimanche le 1 juin			
09:00 – 13:00	C-SOLAS (Canadian Surface Ocean Lower Atmosphere Study) Board of Directors / Conseil d'administration de SOLAS	Leah Terry	Pinnacle
09:00 – 13:00	CNC/SCOR (Canadian National Committee / Comités nationaux canadiens du Scientific Committee on Oceanic Research)	Dick Stoddart	Panorama
09:30 – 11:00	CMOS Publications Committee SCMO Comité des publications	Richard Asselin	Joliet
11:00 – 13:00	CMOS Private Sector Committee SCMO Comité du secteur privé	Susan Woodbury	Victoria
13:00 – 15:00	CMOS University and Professional Education Committee / SCMO Comité d'éducation professionnelle et universitaire	Peter Bartello	Joliet
13:00 – 15:00	CMOS Scientific Committee SCMO Comité scientifique	Ken Denman	Victoria
13:00 – 16:30	CNC/ECOR (Canadian National Committee / Comités nationaux canadiens du Engineering Committee on Oceanic Resources)	Dick Stoddart	Panorama
13:00 – 16:00	C-SOLAS (Canadian Surface Ocean Lower Atmosphere Study) Science Advisory Committee / Comité scientifique consultatif	Leah Terry	Pinnacle
15:00 – 16:30	CMOS Centres and Chapters & CMOS Membership Committee / Présidents des Centres de la SCMO & Comité d'adhesion	Allyn Clarke / Ron Bianchi	Joliet
15:00 – 16:00	CMOS SPEC (Schools and Public Education Committee) / SCMO CEPS (Comité d'éducation publique et scolaire)	Gilles Simard	Chaudière
16:30 – 18:00	CMOS Council Conseil SCMO	Ron Bianchi	Pinnacle
Tuesday June 3 / mardi le 3 juin			
10:30 -12:00	CFCAS Annual Meeting Assemblée annuelle de la FCSCA	Dawn Conway	Chaudière
19:30 – 21:30	CMOS Annual General Meeting Assemblée générale annuelle de la SCMO	Ron Bianchi	Ballrooms B & C
Thursday June 5/ jeudi le 5 juin			
12:15 – 13:30	CMOS Private Sector Meeting SCMO Comité de secteur privé	Susan Woodbury	Richelieu
16:15 – 17:30	CSAM Annual General Meeting Assemblée générale annuelle de la SCAM	Alan Barr	Panorama

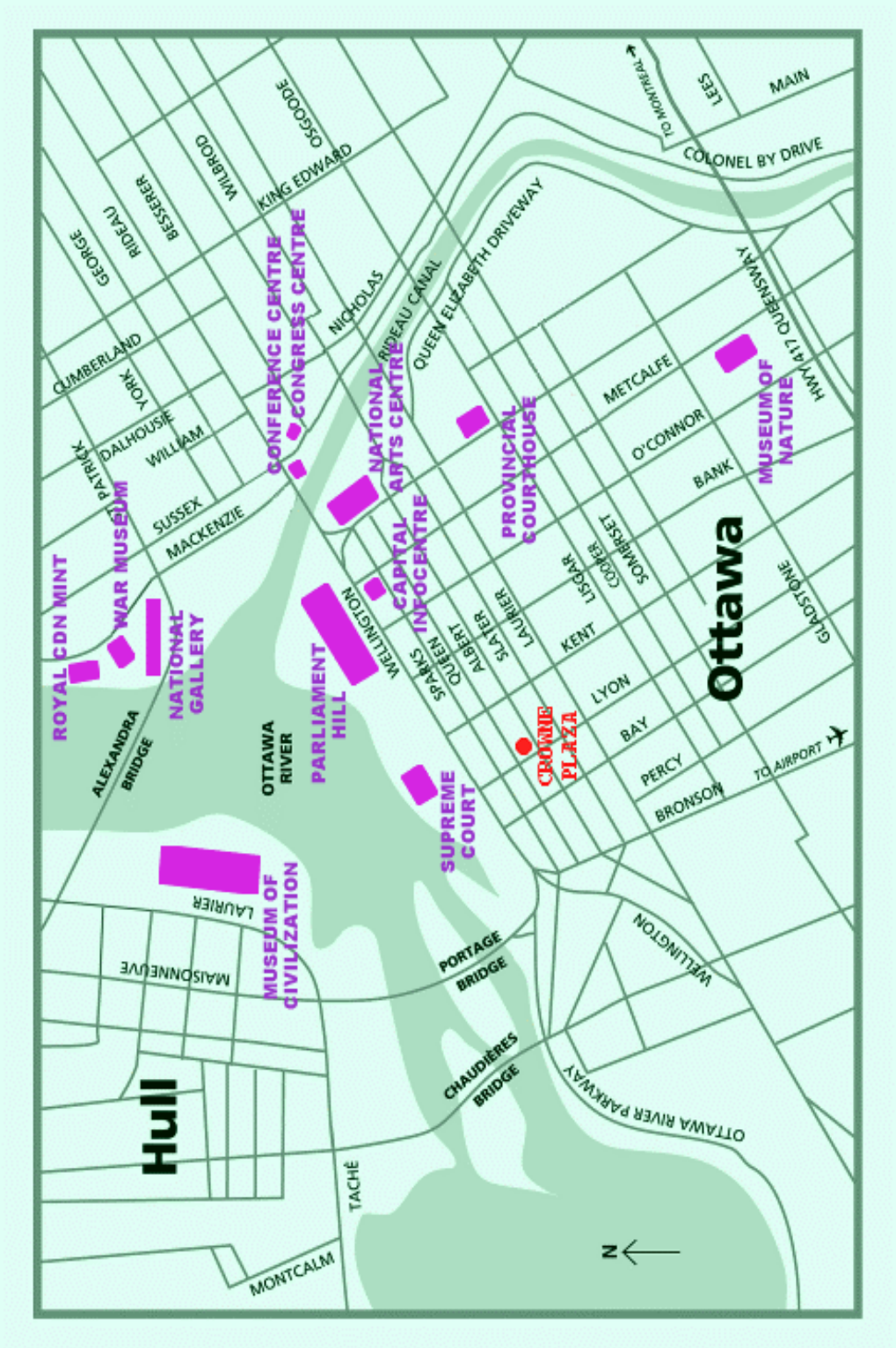
Bursary Recipients

Récipiendaires des bourses

Name	School	Supervisor
Sarah Boon	University of Alberta	Martin Sharp
Max Dupilka	University of Alberta	Gerhard Reuter
Mohammed Elkamash	University of Alberta	Mark Loewen
Guowang Qiu	University of Guelph	Jon Warland
Jun Zhao	Dalhousie University	Jin Yu Sheng
Maheswar Rupakheti	Dalhousie University	Ulrike Lohmann
Erica Key	University of Miami	Peter Minnet
Dieudonne Grodya-Dhechuvi	University of Quebec - Montreal	J.P Blanchet
GyuWon Lee	McGill University	Isztar Zawadski
Nathalie Mathieu	McGill University	Ian Strachan
Laura Wittebol	McGill University	Ian Strachan
Alexandru Stefanof	University of Quebec - Montreal	J.P Blanchet
Cristina Stefanof	University of Quebec - Montreal	J.P Blanchet
Dimitrijevic Milena	University of Quebec - Montreal	Rene Laprise
Marouane Temimi	École de Technologie Supérieure	Robert Leconte
Jan Sedlacek	McGill University	Lawrence Mysak
Sun Hee Cho	York University	Diane Michelangeli
Mark Gordon	York University	Peter Taylor
Lisa Alexander	York University	Peter Taylor
Xiurong Sun	York University	Peter Taylor
Kemp Simon	York University	Peter Taylor
Zhuming Ying	York University	John McConnell
Debra Wunch	University of Toronto	J.R. Drummond
Sergiy Savelyev	York University	Peter Taylor
Sarah Roberts	University of British Columbia	Tim Oke
Sean Fleming	University of British Columbia	Garry Clarke
Judi Kreyzanowski	University of British Columbia	Ian Mckendry

Downtown Map

Plan de Centre Ville



Week at a Glance

Monday June 2	Tuesday June 3	Wednesday June 4	Thursday June 5
Plenary 1-A 08:30-10:00 (B-Room B/C)	Plenary 2-A 8:30-10:00 (B-Room B/C)	Plenary 3-A 8:30-10:00 (B-Room B/C)	Plenary 4-A 8:30-10:00 (B-Room B/C)
Health: Break 10:00-10:30	Health: Break 10:00-10:30	Health: Break 10:00-10:30	Health: Break 10:00-10:30
Session 1-B 10:30-12:30	Session 2-B 10:30-12:00	Session 3-B 10:30-12:30	Session 4-B 10:30-12:15
1-B-1 (Jo/Fro) Climate and Climate Change 1	2-B-1 (Pin) Impacts of Weather (land and ocean) and Climate on Society	3-B-1 (Jo/Fro) Operational Meteorology 1 : Performance Measurement	4-B-1 (Rich) Remote Sensing 1 : Radar Meteorology and Precipitation
1-B-2 (Pin) Numerical Weather Prediction - COMM 1	2-B-2 (Jo/Fro) Climate and Climate Change 4	3-B-2 (Pan) Chemical Meteorology and Air Quality 1	4-B-2 (Pan) Canadian Society of Agrometeorology 1
1-B-3 (Pan) Private Sector	2-B-3 (Rich) Middle Atmosphere Measurements and Modelling 1	3-B-3 (Chaud) Women in Science and Engineering	4-B-3 (Pin) Mackenzie GEWEX Study
1-B-4 (Rich) Surface Ocean – Lower Atmosphere Study 1	2-B-4 (Pan) Biophysical Studies of Ocean Ecosystems	3-B-4 (Pin) Cryosphere	4-B-4 (Jo/Fro) Operational Oceanography
		3-B-5 (Rich) Middle Atmosphere Measurements and Modelling 4	
Lunch 12:30-13:30	Awards Luncheon 12:00-13:45 (B-room B/C)	Lunch 12:30-13:30	Lunch 12:15-13:30; Poster Session C
Session 1-C 13:30-15:15	Session 2-C 13:45-15:15	Session 3-C 13:30-15:15	Session 4-C 13:30 – 15:15
1-C-1 (Jo/Fro) Climate and Climate Change 2	2-C-1(Pan) Weather, Climate and Health 1	3-C-1 (Jo/Fro) Operational Meteorology 2 : Forecasting Tools	4-C-1 (B-room B) Remote Sensing 2 : Coastal Zones and Oceans
1-C-2 (Pin) Numerical Weather Prediction - COMM 2	2-C-2 (Jo/Fro) Climate and Climate Change 5	3-C-2 (Pan) Chemical Meteorology and Air Quality 2	4-C-2 (Pan) Canadian Society of Agrometeorology 2
1-C-3 (Pan) Icing Effects on Aircraft and Structures (starts at **13:15**)	2-C-3 (Rich) Middle Atmosphere Measurements and Modelling 2	3-C-3 (Chaud) Boundary Layer 1 : Surface-Atmosphere Interactions	4-C-3 (B-room C) Operational Meteorology 4 : Performance Measurement II
1-C-4 (Rich) Surface Ocean – Lower Atmosphere Study 2	2-C-4 (Pin) Air-Sea Interactions and Waves 1	3-C-4 (Pin) Arctic Oceanography and Meteorology 1	4-C-4 (Pin) Coastal Oceanography 1
	2-C-5 (Chaud) Impacts of Weather (land and ocean) and Climate on Society 2	3-C-5 (Rich) Middle Atmosphere Measurements and Modelling 5	
Health Break 15:15-15:45	Health Break 15:15-15:45	Health Break 15:15-15:45	Health Break 15:15-15:45
Session 1-D 15:45-17:45	Session 2-D 15:45-17:45	Session 3-D 15:45-17:30	Session 4-D 15:45 – 17:30
1-D-1 (Jo/Fro) Climate and Climate Change 3	2-D-1(Pan) Weather, Climate and Health 2	3-D-1 (Jo/Fro) Operational Meteorology 3 : Processes	4-D-1 (B-room B) Remote Sensing 3 : Atmosphere
1-D-2 (B-room B) The Atmosphere on Mars	2-D-2 (Jo/Fro) Climate and Climate Change 6	3-D-2 (Pan) Chemical Meteorology and Air Quality 3	4-D-2 (Pan) Canadian Society of Agrometeorology 3
1-D-3 (B-room C) Road Weather Systems	2-D-3 (Rich) Middle Atmosphere Measurements and Modelling 3	3-D-3 (Chaud) Boundary Layer 2 : Simulation and Observation	4-D-3 (B-room C) Operational Meteorology 5 : MSC Update
1-D-4 (Rich) Surface Ocean – Lower Atmosphere Study 3	2-D-4 (Pin) Air-Sea Interactions and Waves 2	3-D-4 (Pin) Arctic Oceanography and Meteorology 2	4-D-4 (Pin) Coastal Oceanography 2
		3-D-5 (Rich) Geophysical Fluid Dynamics (**to 18:00)**	
	Poster Session A 17:30-18:30	Poster Session B 17:30-18:30	
Icebreaker 18:00 (Pan & Pin)	Annual General Meeting (B-room B/C) 19:30 – 21:30	Banquet (B-room B/C) cocktails 18:30; dinner 19:30	

Room Abbreviations and Locations

Name	Abbreviation	Level
Chaudière	Chaud	Conference
Joliet/Frontenac	Jo/Fro	Conference
Panorama	Pan	Penthouse
Pinnacle	Pin	Penthouse
Richelieu	Rich	Conference
Ballroom A	B-room A	Lower
Ballroom B	B-room B	Lower
Ballroom C	B-room C	Lower

Aperçu de la semaine

lundi 2 juin	mardi 3 juin	mercredi 4 juin	jeudi 5 juin
Plénière 1-A 08h30-10h00 (B-Room B/C)	Plénière 2-A 8h30-10h00 (B-Room B/C)	Plénière 3-A 8h30-10h00 (B-Room B/C)	Plénière 4-A 8h30-10h00 (B-Room B/C)
Pause santé 10h00-10h30	Pause santé 10h00-10h30	Pause santé 10h00-10h30	Pause santé 10h00-10h30
Session 1-B 10h30-12h30	Session 2-B 10h30-12h00	Session 3-B 10h30-12h30	Session 4-B 10h30-12h15
1-B-1 (Jo/Fro) Le climat et changement de climat 1	2-B-1 (Pin) Les impacts du temps (terre et mer) et du climat sur la société	3-B-1 (Jo/Fro) Météorologie opérationnelle 1 : mesure de la performance	4-B-1 (Rich) Télédétection 1 : Météorologie radar et précipitation
1-B-2 (Pin) Prévision numérique du temps - COMM 1	2-B-2 (Jo/Fro) Le climat et changement de climat 4	3-B-2 (Pan) Météorologie chimique et Qualité de l'air 1	4-B-2 (Pan) Société canadienne d'agrométéorologie 1
1-B-3 (Pan) Secteur privé	2-B-3 (Rich) Mesures et modélisation de l'atmosphère moyenne 1	3-B-3 (Chaud) Les femmes en sciences et en génie	4-B-3 (Pin) Étude GEWEX Mackenzie
1-B-4)Rich) Surface de l'océan – Étude de la basse atmosphère 1	2-B-4 (Pan) Études biophysiques des écosystèmes marins	3-B-4 (Pin) Cryosphère	4-B-4 (Jo/Fro)Océanographie opérationnelle
		3-B-5 (Rich) Mesures et modélisation de l'atmosphère moyenne 4	
Dîner 12h30-13h30	Dîner des récompenses 12h00-13h45 (B-room B/C)	Dîner 12h30-13h30	Dîner 12h15-13h30; session d'affiches C
Session 1-C 13h30-15h15	Session 2-C 13h45-15h15	Session 3-C 13h30-15h15	Session 4-C 13h30 – 15h15
1-C-1 (Jo/Fro) Le climat et changement de climat 2	2-C-1 (Pan) Temps, climat et santé 1	3-C-1 (Jo/Fro) Météorologie opérationnelle 2 : outils de prévision	4-C-1 (B-room B) Télédétection 2 : Zones côtières et océans
1-C-2 (Pin) Prévision numérique du temps - COMM 2	2-C-2 (Jo/Fro) Le climat et changement de climat 5	3-C-2 (Pan) Météorologie chimique et Qualité de l'air 2	4-C-2 (Pan) Société canadienne d'agrométéorologie 2
1-C-3 (Pan) Effets du givrage sur les aéronefs et les structures (commence à **13h15**)	2-C-3 (Rich) Mesures et modélisation de l'atmosphère moyenne 2	3-C-3 (Chaud) Couche limite 1 : interactions surface-atmosphère	4-C-3 (B-room C) Météorologie opérationnelle 4 : Mesures de la performance II
1-C-4 (Rich) Surface de l'océan – Étude de la basse atmosphère 2	2-C-4 (Pin) Interactions air mer et vagues 1	3-C-4 (Pin) Océanographie et météorologie arctique 1	4-C-4 (Pin) Océanographie côtière 1
	2-C-5 (Chaud) Les impacts du temps (terre et mer) et du climat sur la société 2	3-C-5 (Rich) Mesures et modélisation de l'atmosphère moyenne 5	
Pause santé 15h15-15h45	Pause santé 15h15-15h45	Pause santé 15h15-15h45	Pause santé 15h15-15h45
Session 1-D 15h45-17h45	Session 2-D 15h45-17h45	Session 3-D 15h45-17h30	Session 4-D 15h45 – 17h30
1-D-1 (Jo/Fro) Le climat et changement de climat 3	2-D-1 (Pan) Temps, climat et santé 2	3-D-1 (Jo/Fro) Météorologie opérationnelle 3 : Processus	4-D-1 (B-room B) Télédétection 3 : atmosphère
1-D-2 (B-room B) L'atmosphère sur Mars	2-D-2 (Jo/Fro) Le climat et changement de climat 6	3-D-2 (Pan) Météorologie chimique et Qualité de l'air 3	4-D-2 (Pan) Société canadienne d'agrométéorologie 3
1-D-3 (B-room C) Systèmes météo route	2-D-3 (Rich) Mesures et modélisation de l'atmosphère moyenne 3	3-D-3 (Chaud) Couche limite 2 : simulation et observation	4-D-3 (B-room C) Météorologie opérationnelle 5 : nouvelles du SMC
1-D-4 (Rich) Surface de l'océan – étude de la basse atmosphère 3	2-D-4 (Pin) Interactions air mer et vagues 2	3-D-4 (Pin) Océanographie et météorologie arctique 2	4-D-4 (Pin) Océanographie côtière 2
		3-D-5 (Rich) Dynamique des fluides géophysiques **(à 18:00)**	
	Session d'affiches A 17:30-18:30	Session d'affiches B 17:30-18:30	
Cocktail de bienvenue 18:00 (Pan & Pin)	Assemblée générale annuelle de la SCMO (B-room B/C) 19 :30 – 21 :30	Banquet (B-room B/C) cocktails 18:30; repas 19:30	

Abréviations et niveaux des salles

Nom	Abréviation	Niveau
Chaudière	Chaud	Conférence
Joliet/Frontenac	Jo/Fro	Conférence
Panorama	Pan	Penthouse
Pinnacle	Pin	Penthouse
Richelieu	Rich	Conférence
Ballroom A	B-room A	Inférieur
Ballroom B	B-room B	Inférieur
Ballroom C	B-room C	Inférieur

Monday June 2 lundi 2 juin

SESSION 1-A Plenary / Plénière : Room / Salle Ballrooms B & C		Chair / Président : Ron Bianchi,Charles Lin
8:30	Welcome and Introduction / Mot de bienvenue et introduction	
8:40	Invited Opening Speaker / Présentation d'ouverture invité	**Hon. David Anderson**
09:00	Invited / Invité 1-A-1 ***Monitoring Climate Change and Variations: Progress and Challenges***	**Tom Karl**
09:30	Invited / Invitée 1-A-2 ***Sharing Science with the Public at a National Research Laboratory***	**R. M. Johnson**
10:00 – 10:30	Health Break / Pause santé	

Room Salle	**Joliet/Frontenac (Conference Level)**	**Pinnacle (Penthouse Level)**	**Panorama (Penthouse Level)**	**Richelieu (Conference Level)**
10:30 – 12:30	**1-B-1** **Climate and Climate Change 1 / Le climat et changement de climat 1** Chair / Président : Rob Cross	**1-B-2** **Numerical Weather Prediction - COMM 1 / Prévision numérique du temps - COMM 1** Chair / Président : Stéphane Bélair	**1-B-3** **Private Sector / Secteur privé** Chair / Président : Susan Woodbury	**1-B-4** **Surface Ocean – Lower Atmosphere Study 1 / Surface de l'océan – Étude de la basse atmosphère 1** Chair / Président : Bill Miller
10:30	1-B-1.1 *GEWEX and the Water Cycle* Ronald Stewart, Invited	1-B-2.1 COMM: *Meteorological Model, Tools, Data and Support for Reseachers, an Update* Stéphane Chamberland	1-B-3.1-7 *Private Sector Panel Discussion: Cashing in on Corporate Canada?*	1-B-4.1 *The Role of Marine Storms in Air-sea Gas Transfer* William Perrie
10:45	1-B-1.2 A *Technique to Detect Microclimatic Inhomogeneities in Historical Temperature Records* Kathryn Runnalls	1-B-2.2 *The Evolution of Elliptic Solvers in MC2* Stephen Thomas		1-B-4.2 *Numerical Study on Uptake and Spreading of Chlorofluorocarbons in the Northwest Atlantic* Ocean Jun Zhao
11:00	1-B-1.3 *Generic Homogeneity Test for Climate Time Series Data* Jean Gagnon	1-B-2.3 *Finescale Orography and the MC2 Semi-Lagrangian Scheme* Claude Girard		1-B-4.3 *Evaluation of a New Model of DOM Dynamics in the Surface Ocean* Markus Pahlow
11:15	1-B-1.4 *Evaluation of Geographical Positioning Systems to Determine Diurnal Trends in Integrated Atmospheric Moisture* Craig Smith	1-B-2.4 *High-resolution Real-time Numerical Weather Prediction and Verification of Near Shore Winds over Lake Ontario* Zuohao Cao	1-B-3.1-7 *Private Sector Panel Discussion: Cashing in on Corporate Canada (continued)*	1-B-4.4 *The Photochemical Production of Dissolved Inorganic Carbon in the Delaware Estuary* Jane Sherrard
11:30	1-B-1.5 *Simplified Nonlinear Principal Component Analysis, with Applications to Climate Datasets* Beiwei Lu	1-B-2.5 *Integrating an Urban Parameterization with MC2 to Simulate Low-level Urban Temperature Distributions* E. Krayenhoff		1-B-4.5 *Development of a Three-dimensional Physical-Biological Model for the North Atlantic* Svetlana Losa

11:45	1-B-1.6 *Simulation of Natural Millennial-scale Climate Variability from the Early Holocene (8 Kyr BP) to the Pre-industrial Period (1700 AD) Using the McGill Paleoclimatic Model* Yi Wang	1-B-2.6 *Limited Area Modelling with GEMDM* Michel Desgagne		1-B-4.6 *Seasonal Retrieval of Chlorophyll-a Concentration in the Northwest Atlantic Zone Using Remotely-Sensed Data: Application to the Spring Season* Emmanuel Devred
12:00	1-B-1.7, 8 *Tribute to Dr. Ken Hare* Peter Adams, Invited	1-B-2.7 *Latest Developments of Very High Resolution GEM-LAM Model Over Mountainous Terrain* Uwe Gramann		1-B-4.7 *Modelling the July 2002 SERIES Iron Fertilization Experiment* Kenneth Denman
12:15				
12:30 – 13:30	Lunch / Dîner			
Room Salle	**Joliet/Frontenac (Conference Level)**	**Pinnacle (Penthouse Level)**	**Panorama (Penthouse Level)**	**Richelieu (Conference Level)**
13:15 – 15:15	**1-C-1** **Climate and Climate Change 2 / Le climat et changement de climat 2** Chair / Président : Allyn Clarke	**1-C-2** **Numerical Weather Prediction - COMM 2 / Prévision numérique du temps – COMM 2** Chair / Président : Louis Lefaivre	**1-C-3** **Icing Effects on Aircraft and Structures / Effets du givrage sur les aéronefs et les structures** Chair / Président : Ed Lozowski	**1-C-4** **Surface Ocean – Lower Atmosphere Study 2 / Surface de l'océan – Étude de la basse atmosphère 2** Chair / Président : Frank Whitney
13:15			1-C-3.1 *The Alliance Icing Research Study I (AIRS I)* George Isaac	
13:30	1-C-1.1 *Effects of Shallow Convection on Cloud Amounts and Radiative Fluxes in the CCCma GCM* Norman McFarlane	1-C-2.1 *Spectral and Wavelet Analysis of Precipitation from Models and Radar* Charles Lin	1-C-3.2 *Aircraft Icing Environments in Canadian Winter Clouds* Stewart Cober	1-C-4.1 *An Unusual Climate Event in the Gulf of Alaska: The View from Argo* Howard Freeland
13:45	1-C-1.2 *Trade Cumulus Cloud Parameterization in Large-scale Models: Results from Large Eddy Simulations* Ming Zhao	1-C-2.2 *The Direct Assimilation of GOES (Infrared) and AMSU-B (Microwave) Radiances in 3D-Var at CMC* Clément Chouinard	1-C-3.3 *Matching Ground-Based Radar Data to In-situ Aircraft Measurements* Peter Rodriguez	1-C-4.2 *Silicon Cycling in the Gulf of Alaska* Frank Whitney
14:00	1-C-1.3 *The Variability of Modelled Tropical Precipitation* Norman McFarlane	1-C-2.3 *Development of a Global Mesoscale Model for Medium-range Weather Forecasting at the Canadian Meteorological Centre* Stéphane Bélair	1-C-3.4 *Discrete Modelling of Ice Accretion under In-flight Icing Conditions* Krysztof Szilder	1-C-4.3 *The Response of Phytoplankton to the Addition of Iron into the Otherwise Iron-limited Waters of the Subarctic NE Pacific Ocean* Nelson Sherry

14:15	1-C-1.4 *Nonlinearity of Extratropical Response to Tropical Forcing* Hai Lin	1-C-2.4 *Surface Modeling and Assimilation in the Canadian Global-scale Model for Medium-Range Weather Forecast at the Canadian Meteorological Centre* Francois Lemay	1-C-3.5 *Preliminary Results from the Alliance Icing Research Study 1.5 (AIRS 1.5)* George Isaac	1-C-4.4 *Microbial Response to a Mesoscale Fe Enrichment in the Northeast Subarctic Pacific: Growth* Michelle Hale
14:30	1-C-1.5 A *Parameterization of Solar Energy Disposition in the Climate System* Zhaomin Wang	1-C-2.5 *Small-scale Inner Core Structures and Wind Streaks in a Simulated Hurricane* Peter Yau	1-C-3.6 *Validation of a GOES Satellite Icing Algorithm with In-situ and Ground Based Observations During AIRS 1.5* Ismail Gultepe	1-C-4.5 *Stable Nitrogen Isotope Dynamics of a Phytoplankton Bloom: Results from the SERIES Experiment in the North Pacific Ocean.* Joseph Needoba
14:45	1-C-1.6 *On the Sensitivity of Modelled Precipitation to Closure Conditions for Cumulus Parameterisations* Virginie Lorant	1-C-2.6 *Numerical Simulation of a Severe Hailstorm using a Double-moment Microphysics Scheme* Jason Milbrandt	1-C-3.7 *Aurora as an Interface to the Airport Vicinity Icing and Snow Advisor (AVISA)* Brian Greaves	1-C-4.6 *SERIES (Sub-arctic Ecosystem Response to Iron Enrichment Study) in HNLC Waters in Northeast Pacific Ocean* C.S. Wong
15:00	1-C-1.7 *Transient Eddies Simulated in the CCCma GCMs: Eastward and Westward Moving Waves* *Jian* Sheng	1-C-2.7 *Development of a New Bulk Mixed-phase Microphysical Scheme* Wanda Szyrmer	1-C-3.8 *Construction of the Airport Vicinity Icing and Snow Advisor (AVISA)* Norbert Driedger	1-C-4.7 *The Response of DMS(P) Production Rates to Fe Enrichment in the NE Pacific: A Shipboard Microcosm Experiment* Michael Scarratt
15:15 – 15:45	Health Break / Pause santé			
Room Salle	**Joliet/Frontenac (Conference Level)**	**Ballroom B (Lower Level)**	**Ballroom C (Lower Level)**	**Richelieu (Conference Level)**
15:45 – 17:45	**1-D-1** **Climate and Climate Change 3 / Le climat et le changement du climat 3** Chair / Président : Rob Cross	**1-D-2** **The Atmosphere on Mars / L'atmosphère sur Mars** Chair / Président : John McConnell	**1-D-3** **Road Weather Systems / Systèmes météo route** Chair / Président : Paul Delannoy	**1-D-4** **Surface Ocean – Lower Atmosphere Study 3 / Surface de l'océan – étude de la basse atmosphère 3** Chair / Président : Moire Wadleigh
15:45	1-D-1.1 *The Nonlinear ENSO Mode and its Interdecadal Changes* Aiming Wu	1-D-2.1 *Mars Atmosphere: on the Third Planet from the Sun* John McConnell	1-D-3.1 *Developing an RWIS Network for Alberta's National Highway System* Mark Pinet	1-D-4.1 *SERIES - Influence of Iron Fertilisation on DMS Production: An Unexpected Twist to the Ocean-climate Connection* Maurice Levasseur

16:00	1-D-1.2 *Parameterization of Subsurface Temperatures in the Lamont Ocean Model using Neural Networks* Shuyong Li	1-D-2.2 *Development of a Mars Spectral General Circulation Model* Youssef Moudden	1-D-3.2,3 *The Winter Road Maintenance Decision Support System (MDSS) Project Overview and Current Status* William Mahoney, Invited	1-D-4.2 *Determination of Apparent Quantum Yield Spectra for Photosensitized Degradation of Dimethylsulfide (DMS) in Northeastern Subarctic Pacific Ocean* René-Christian Bouillon
16:15	1-D-1.3 *Stochastic Modeling of Precipitation for Canada* Hui Wan	1-D-2.3 *Modeling Dust and Clouds on Mars Using a One-dimensional Aerosol Model* Jagurti Pathak		1-D-4.3 *Trends in Atmospheric Dimethylsulphide During SERIES* Moire Wadleigh
16:30	1-D-1.4 *Wind Energy Mapping as a Regional Climate Modeling Problem* Robert Benoit	1-D-2.4 *On Modelling the Martian Atmospheric Boundary Layer* Peter Taylor	1-D-3.4,5 *The Winter Road Maintenance Decision Support System (MDSS) Road Conditional and Treatment Module (RCTM)* Robert Hallowell, Invited	1-D-4.4 *Sulphur Dioxide, Aerosol Sulphate and Methanesulphonic Acid During SERIES* Ann-Lise Norman
16:45	1-D-1.5 *Developing Daily Climate Scenarios for Agricultural Impact Studies* Budong Qian	1-D-2.5 *Tides in the Martian Atmosphere: A Survey of Observations and Modelling* Charles McLandress		1-D-4.5 *Characterization of Aerosol Over the North Pacific* Lisa Phinney
17:00	1-D-1.6 *Statistical Downscaling Models Robustness: A Regional Case Study Approach for Quebec* Jenna Goldstein	1-D-2.6 *The Mars Imager for Cloud and Aerosol (MICA) for the 2007 Mars Volcanic Emission and Life (MARVEL) Scout Proposal* Vicky Hipkin	1-D-3.6 *Fog: Impact on Road Transportation and Mitigation Options* Bruce Whiffen	1-D-4.6 *Optical Properties of Aerosol Particles over the Northeast Pacific* Julia Marshall
17:15	1-D-1.7 *Building Climate Change Scenarios of Temperature and Precipitation - A Pilot Project for Canada using the Statistical Downscaling Model (SDSM)* Gary Lines	1-D-2.7 *Northern Light - A Canadian Mars Lander* Brendan Quine	1-D-3.7 *Wind Mapping for Canada with WEST* Robert Benoit	1-D-4.7 *Stronger Constraints on the Anthropogenic Indirect Aerosol Effect* Ulrike Lohmann
17:30	1-D-1.8 *A Synoptic Climatological Approach to Assess Possible Impacts of Climate Change on Freezing Rain in South Central Canada* Shouquan Cheng	1-D-2.8 *Lidar Applications for Mars Atmospheric Studies* Allan Carswell		1-D-4.8 *Overview of posters* (three posters on display in the room) Moire Wadleigh
18:00	Icebreaker / Cocktail de bienvenue			

SESSION 2-A Plenary / Plénière : Room / Salle Ballrooms B & C				Chair / Président : Savi Narayanan
08:30	Invited / Invité 2-A-1 ***Forecasting the Nation's Health - the UK Met Office Experience in Predicting Daily Workload in the British Health System***			**William Bird**
09:00	Invited / Invitée 2-A-2 ***Climate Change Impacts and Adaptation - DFO's Response to the Challenge***			**Wendy Watson-Wright**
09:30	Invited / Invitée 2-A-3 ***Measurements of Chemical Constituents in the Stratosphere from Balloon-borne and Ground-based Instruments***			**Kimberly Strong**
10:00 – 10:30	Health Break / Pause santé			
Room Salle	**Pinnacle (Penthouse Level)**	**Joliet/Frontenac (Conference Level)**	**Richelieu (Conference Level)**	**Panorama (Penthouse Level)**
10:30 – 12:00	**2-B-1 Impacts of Weather (land and ocean) and Climate on Society / Les impacts du temps (terre et mer) et du climat sur la société** Chair / Président : Eric Taylor	**2-B-2 Climate and Climate Change 4 / Le climat et changement de climat 4** Chair / Président : Allyn Clarke	**2-B-3 Middle Atmosphere Measurements and Modelling 1 / Mesures et modélisation de l'atmosphère moyenne 1** Chair / Président : Kimberly Strong	**2-B-4 Biophysical Studies of Ocean Ecosystems / Études biophysiques des écosystèmes marins** Chair / Président : Susan Allen
10:30	2-B-1.1 *Scenarios of Climate Change for Impacts and Adaptation* Philippe Gachon, Invited	2-B-2.1 *Diagnosis of Simulated and Observed Extra-tropical Cyclones* Steve Lambert	2-B-3.1, 2 *Modelling of Chemical-climate Coupling in the Middle Atmosphere* Theodore Shepherd, Invited	2-B-4.1 *Biological Impact of Eddies in the Gulf of Alaska, based on SeaWiFS and Satellite Altimetry Observations* Peter Brickley
10:45	2-B-1.2 *Preventing Extreme Weather Events from Becoming Disasters* Paul Kovacs	2-B-2.2 *Cloudiness Trends in Canada* Ewa Milewska		2-B-4.2 *Physical Processes of Haida Eddies of the Eastern Gulf of Alaska: Formation, Transport and Currents* William Crawford
11:00	2-B-1.3, 4 *Climate and Health Issues in the Toronto-Niagara Region: Assessing the Implications of Climate Change for Health Infrastructure* Quentin Chiotti	2-B-2.3 *Climatological Analysis of Northern Hemisphere Anticyclones* Lily Ioannidou	2-B-3.3 *SWIFT: The Stratospheric Wind Interferometer for Transport studies* Ian McDade	2-B-4.3 *Estimates of Secondary Production from NPZ-type and Copepod Life History Models : Are the Two Approaches Ecologically Coherent?* Bruno Zakardjian
11:15		2-B-2.4 *Oceanic Signatures and Long-Term Trends in the Climate over the Lower Mainland of British Columbia* Ruping Mo	2-B-3.4 *The Canadian Middle Atmosphere Model : Results and Model Development* Jean de Grandpré	2-B-4.4 *Quantifying Changes in Zooplankton Community Structure and Secondary Production in the Strait of Georgia using an Optical Plankton Counter* Tomas Bird

11:30	2-B-1.5 *Impacts of Seasonal Variability and Climate Change on Foodborne Disease* Manon Fleury	2-B-2.5 *Trend Analysis of Canadian Pan Evaporation Data* Ron Hopkinson	2-B-3.5, 6 *The Canadian Middle Atmosphere Model (CMAM) Data Assimilation Scheme* Soroja Polavarapu, Invited	2-B-4.5 *Revisiting the Role of Fresh Water in the Timing of the Spring Bloom in the Strait of Georgia* Susan Allen	
11:45	2-B-1.6 *Canadian Weather through the Eyes of Canadian Artists* Phil Chadwick				
12:00 – 13:45	Awards Luncheon / Dîner des récompenses				
Room Salle	**Panorama** **(Penthouse Level)**	**Joliet/Frontenac** **(Conference Level)**	**Richelieu** **(Conference Level)**	**Pinnacle** **(Penthouse Level)**	**Chaudière** **(Conference Level)**
13:45 – 15:15	**2-C-1** **Weather, Climate and Health 1 / Temps, climat et santé 1** Chair / Président : Denis Bourque	**2-C-2** **Climate and Climate Change 5 / Le climat et changement de climat 5** Chair / Président : Daniel Caya	**2-C-3** **Middle Atmosphere Measurements and Modelling 2 / Mesures et modélisation de l'atmosphère moyenne 2** Chair / Président : Ted Shepherd	**2-C-4** **Air-Sea Interactions and Waves 1 / Interactions air mer et vagues 1** Chair / Président : Peter Smith	**2-C-5** **Impacts of Weather (land and ocean) and Climate on Society 2 / Les impacts du temps (terre et mer) et du climat sur la société 2** Chair / President : Tanuja Kulkarni
13:45	2-C-1.1 *Associations Between Meteorological Factors and Emergency Room Visits in a Canadian Children's Hospital* Paul Villeneuve	2-C-2.1, 2 *Simulations of Regional Climate with High-Resolution Global Climate Models* P. Duffy, Invited	2-C-3.1,2 *Measurements of ClO in the Polar Lower Stratosphere from the UARS and EOS Aura Microwave Limb Sounder Experiments* Michelle Santee, Invited	2-C-4.1, 2 *Report of an Inter-departmental Panel on Operational Canadian Coupled Modelling Capacity* Hal Ritchie, Invited	2-C-5.1, 2 *Lake-Ice Thickness, Active-Layer Depth, and Climate Variability, Richards Island, Western Arctic Coast, Canada* Chris Burn
14:00	2-C-1.2 *Ophthalmological Emergency Examinations, Weather and Environmental Conditions; Paris Area, 1997 - 2000: A Multivariate Statistical Analysis* Jean-Claude Cohen				
14:15	2-C-1.3 *Relationship of Seasonality and Heart Failure in Canada* Helen Johansen	2-C-2.3 *Resolved Scales and Nonlinear Interactions in Limited-area Models* René Laprise	2-C-3.3, 4 *Remote Sensing of the Middle Atmosphere by OSIRIS and SCIAMACHY Measurements of Limb-scattered Solar Radiation* Christian von Savigny, Invited	2-C-4.3, 4 *High Latitude Air-Sea Interaction: Lessons Learned from the Labrador Sea Deep Ocean Convection Experiment* G.W.K. Moore, Invited	2-C-5.3 *Socio-economic Implications of a Changing Climate in the Grat Lakes – St. Lawrence Region* Linda Mortch

14:30	2-C-1.4 *Are High-impact Weather Events Associated with Waterborne Disease Outbreaks in Canada?* Kate Thomas	2-C-2.4 *Validation of the Nesting Technique of a Nested Regional Climate Model (RCM) by the Protocol "Big Brother" During the Summer Season* Milena Dimitrijevic			2-C-5.4 *Assessing Climate Change in an Integrated Watershed Management Framework* Jim Byrne
14:45	2-C-1.5 *The Risk of Being Injured While Driving Under the Influence of Weather* Brian Mills	2-C-2.5 *Regional Snowpack Modelling Over Canadian Landscapes* Murray MacKay	2-C-3.5 *Ground-based FTIR Atmospheric Absorption Measurements of Nitric Acid in the High Arctic above Eureka, Canada, throughout the Winter of 2001/2002* Hans Fast	2-C-4.5 *Energy-flux Balances in Surface Waves* Donald Resio	2-C-5.5 *Projecting Climate Change-induced Impacts on Future Canadian Fire Regimes* Brian Stocks
15:00	2-C-1.6 *Overview of Posters by Session Chair*	2-C-2.6 *Sensitivity of the Canadian Regional Climate Model to Cloud and Land Surface formulations* Arturo Quintanar	2-C-3.6 *Retrieval of Nitric Acid and Ozone Profiles from Low-resolution Emission Radiometers Flown on Three MANTRA Balloon Missions* Matthew Toohey		2-C-5.6 *Le Sahel; L'Agriculture, les Ressources en Eau, le Pastoralisme et L'Environnement Intégré Face à la Variabilité du Climat et à ses Changements* André Cotnoir
15:15 – 15:45	Health Break / Pause santé				

Room Salle	**Panorama** **(Penthouse Level)**	**Joliet/Frontenac** **(Conference Level)**	**Richelieu** **(Conference Level)**	**Pinnacle** **(Penthouse Level)**
15:45 – 17:45	**2-D-1** **Weather, Climate and Health 2 /Temps, climat et santé 2** Chair / Président : Denis Bourque	**2-D-2** **Climate and Climate Change 6 / Le climat et changement de climat 6** Chair / Président : René Laprise	**2-D-3** **Middle Atmosphere Measurements and Modelling 3 / Mesures et modélisation de l'atmosphère moyenne 3** Chair / Président : Ian McDade	**2-D-4** **Air-Sea Interactions and Waves 2 /** **Interactions air mer et vagues 2** Chair / Président : Hal Ritchie
15:45	2-D-1.1 *New Guideline on Frostbite Development and the Effect of Wind Chill* Michel Ducharme	2-D-2.1 *The Preliminary Results from a 5-year Simulation using Canadian Regional Climate Model over Pan-Canadian Area* Yanjun Jiao	2-D-3.1, 2 *Off-line 3D Chemical Transport Modelling of the Stratosphere: Multi-decadel Simulations of Ozone Variability and Trends* Martyn Chipperfield, Invited	2-D-4.1, 2 *Parameterizing Turbulent Air-Sea Transfer in High-Wind, Spray Conditions* Edgar Andreas, Invited

16:00	2-D-1.2 *Winter Mortility, Climate and Climate Change in U.S. Cities* Robert E Davis	2-D-2.2 *Internal Variability in RCM Simulations over an Annual Cycle* Daniel Caya		
16:15	2-D-1.3 *Climate Change, Health, and Women* Kirsty Duncan	2-D-2.3 *Regional Climate Simulations in the Ouranos Consortium* Daniel Caya	2-D-3.3 *Observational Analysis of the Containment of Antarctic Vortex Air following the Split Ozone Hole of 2002* Jennifer Lukovich	2-D-4.3 *Storm Wind Study II – Air-Sea Interaction on the Grand Banks* Robert Anderson
16:30	2-D-1.4 *Climatology and Long-Term Changes in Ultraviolet Radiation over Canada* Vitali Fioletov	2-D-2.4 *Suitability of the Large-scale Routing Schemes for Use with Regional Climate Models* Laxmi Sushama	2-D-3.4 *Total Ozone Variations over Midlatitudes and on the Global Scale* Vitali Fioletov	2-D-4.4 *Wave-induced Drift in the Coastal Region of the North-West of Baja California* F. Ocampo-Torres
16:45	2-D-1.5 *Impacts of Summer Weather and Air Pollution on Human Mortality in South Central Canada* Shouquan Cheng	2-D-2.5 *The Coupling of Canadian Regional Climate Model (MRCC) with Hudson Bay Regional Ocean Model (ROM)* Minwei Qian	2-D-3.5 *Correlations of Long-lived Chemical Species in a Middle Atmosphere General Circulation Model* David Sankey	2-D-4.5 *The Effect of Coherent Structures on Air-sea Gas Transfer* Kamran Siddiqui
17:00		2-D-2.6 *A Coupled Regional Climate Simulator for the Gulf of St. Lawrence, Canada* Manon Faucher	2-D-3.6 *Comparison Between Chemical Species Measured in the High Arctic During Spring 1999 and 2000 and the Canadian Middle Atmosphere Model* Elham Farahani	2-D-4.6 *Intercomparing Operational Wave Models* Roberto Padilla-Hernandez
17:15		2-D-2.7 *Simulation of Extra-Tropical Storms: Coupling CRCM to a Dynamical Ocean Model* Zhenxia Long	2-D-3.7 *Comparison of Atmospheric Trace Gases Measured Over Toronto Using a Ground-based FTIR Spectrometer with Output from the Canadian Middle Atmosphere Model* Aldona Wiacek	2-D-4.7 *Simulation of Intense North Atlantic Storms: Coupling MC2 to Models for Waves and Sea Spray* Weiqing Zhang
17:30		2-D-2.8 *Hailstorm Modeling Using a Downscaling Technique* Ernest Koffi-Lefeivre	2-D-3.8 *Field-Testing the MAESTRO Instrument from a High-Altitude Balloon* Caroline Nowlan	2-D-4.8 *On the Atmosphere-ocean Dynamics of Extra-tropical Cyclones: Coupling MC2 to an Operational Ocean Model* Xuejuan Ren
17:30 – 18:30	Poster Session A / Session d'affiches A			

Wednesday 4 June — mercredi 4 juin

SESSION 3-A Plenary / Plénière : Room / Salle Ballrooms B & C					Chair / Président : John D. Reid
08:30	Invited / Invité 3-A-1 ***Evaluation of Forecasts of High Impact Weather***				**Harold Brooks**
09:00	Invited / Invité 3-A-2 ***Air Quality Prediction: An Overview of MSC's Program***				**Pierre Dubreuil**
09:30	Invited / Invité 3-A-3 ***SHEBA: The Surface Heat Budget of the Arctic Ocean***				**Donald Perovich**
10:00 – 10:30	Health Break / Pause santé				
Room Salle	**Joliet/Frontenac (Conference Level)**	**Panorama (Penthouse Level)**	**Chaudière (Conference Level)**	**Pinnacle (Penthouse Level)**	**Richelieu (Conference Level)**
10:30 – 12:30	**3-B-1 Operational Meteorology 1 : Performance Measurement / Météorologie opérationnelle 1 : mesure de la performance** Chair / Président : Stuart Cober	**3-B-2 Chemical Meteorology and Air Quality 1 / Météorologie chimique et Qualité de l'air 1** Chair / Président : Philip Blagden	**3-B-3 Women in Science and Engineering / Les femmes en sciences et en génie** Chair / Président : Ann McMillan	**3-B-4 Cryosphere /Cryosphère** Chair / Président : Anne Walker	**3-B-5 Middle Atmosphere Measurements and Modelling 4 / Mesures et modélisation de l'atmosphère moyenne 4** Chair / Président : David Sankey
10:30	3-B-1.1 *Comparaisons Entre les Performances des Modèles de Prévisions des Grand Centres / Comparison of model performances for leading NWP Centres* Tom Robinson	3-B-2.1 *Predicting Particulate Matter in Air Quality over Southern Ontario Using AAA* Ray Yang	3-B-3.1,7 *The Role of Women in Meteorology and Hydrology in the Activities of the World Meteorological Organization* Martha McCulloch	3-B-4.1 *Canadian Long-range Ice Forecasting (CLIF) Initial Work in the Gulf of St. Lawrence* Bernard Miville	3-B-5.1, 2 *Interactions of Atmospheric Trace Gases with Ice: Heterogeneous Reactions and Scavenging* Jonathan Abbatt, Invited
10:45	3-B-1.2 *Verification of the Canadian Ensemble Prediction System* Jacques Montpetit	3-B-2.2 *The Importance of Multiphase Reactions in Urban Tropospheric Chemistry* Surandokht Nikzad		3-B-4.2 *Examining Shifts in Sea Ice Time Series from the Canadian Ice Services Digital Chart Database* Bea Alt	
11:00	3-B-1.3 *Verification* Phil Chadwick	3-B-2.3 *Global Atmospheric Cycling of Mercury* Ashu Dastoor		3-B-4.3 *Performance Evaluation of Two Neural Network-based Models for Predicting Sea Ice Concentration* A. El-Rabbany	3-B-5.3 A *Numerical Model for Polar Stratospheric Clouds and Stratospheric Chemistry* Xihong Wang

11:15	3-B-1.4 *Mesure de performance des prévisions météorologiques forestières* Michel Moreau	3-B-2.4 *Tropospheric Chemical Data Assimilation* Richard Ménard		3-B-4.4 *On the Utility of Diurnal Measurements of Snow Covered First-Year Sea Ice Microwave Scattering for Estimating Surface and Climate State Variables* John Yackel	3-B-5.4 *Atmospheric N2O and its Isotopic Analogues: Elucidating the Role of the Stratosphere Through Models and Measurements* Chris McLinden
11:30	3-B-1.5 *Application of an Objective Method for Evaluating Weather Forecasts on the Canadian Prairies* Julian Brimelow	3-B-2.5 *Aerosol-Cloud Interactions in Marine Stratus Clouds* Irena Paunova		3-B-4.5 *Air Temperature, Snow Depth, and Permafrost Temperature, Mackenzie Delta Area, NWT* Chris Burn	3-B-5.5 *Measurements of the Mid-latitude Stratospheric Photodissociation Rates of O(1D) and NO2 During the MANTRA 2002 Balloon Campaign* Hongjiang Wu
11:45	3-B-1.6 *Some Issues on Probability Forecasting* Ramon de Elia	3-B-2.6 *Testing a Isoprene Mechanism and Chemical Solvers* Hao Wu		3-B-4.6 *Snow Water Equivalent Retrieval over Canadian Regions Using Passive Microwave Satellite Data* Annie Walker	3-B-5.6 *Can We Predict the Fall Turnaround in Zonal Wind over Vanscoy?* Debra Wunch
12:00	3-B-1.7 *Project Phoenix – Preparing Meteorologists for an Intensive Man-Machine Mix* Jim Slipec				3-B-5.7 *On the Limitations of Trajectory-following Photochemical Box Modelling* Kirill Semeniuk
12:15					3-B-5.8 *Modelling Tropospheric Chemistry in the Canadian Middle Atmosphere Model* D. Plummer
12:30-13:30	Lunch / Dîner				
Room Salle	**Joliet/Frontenac (Conference Level)**	**Panorama (Penthouse Level)**	**Chaudière (Conference Level)**	**Pinnacle (Penthouse Level)**	**Richelieu (Conference Level)**
13:30 – 15:15	**3-C-1** **Operational Meteorology 2 : Forecasting Tools / Météorologie opérationnelle 2 : outils de prévision**	**3-C-2** **Chemical Meteorology and Air Quality 2** **Météorologie chimique et Qualité de l'air 2** Chair / Président : Ann	**3-C-3** **Boundary Layer 1 : Surface-Atmosphere Interactions / Couche limite 1 : interactions surface-atmosphère**	**3-C-4** **Arctic Oceanography and Meteorology 1 / Océanographie et météorologie arctique 1** Chair / Président : Daniel	**3-C-5** **Middle Atmosphere Measurements and Modelling 5 / Mesures et modélisation de l'atmosphère moyenne**

	Chair / Président : Isztar Zawadzski	McMillan	Chair / Président : Ian Strachan	Fortier	**5** Chair / Président : Charles McLandress
13:30	3-C-1.1 *Observation and Nowcasting in SCRIBE Claude* Landry	3-C-2.1 *Air Quality Forecasting in Atlantic Canada* William Appleby, Invited	3-C-2.1, 2 *Carbon Exchange from Canadian Peatlands – Perspective and Understanding* Peter Lafleur, Invited	3-C-4.1 *Recovery of the Sea Ice Regime in the Canadian Arctic Islands from the Warm Summer of 1998* Tom Agnew	3-C-5.1 Comparison of Lidar Measurements of Mesospheric Inversion Structures with a General Circulation Model R. Sica
13:45	3-C-1.2 *Utility of a Blowing Snow Model for Operational Forecasts on the Canadian Prairies and Arctic* John Hanesiak	3-C-2.2 *Forecasting Air Quality in the Lower Fraser Basin* Edward Lord, Invited		3-C-4.2 *Comparison of Sea-ice Rheologies in Global Ocean-Atmosphere-Ice Models and the Impact on Decadal Variability* K. Wright	3-C-5.2 *Global Variability of the Mesospheric Temperature Field* Marianna Shepherd
14:00	3-C-1.3 *Evaluation of Hail Size Forecasts Produced Using Prognostic GEM Model Soundings and Hailcast* Julian Brimelow	3-C-2.3 *MAQNET - Multiscale Air Quality Modelling Network Project* John McConnell, Invited	3-C-2.3, 4 *Modelling the Exchange of Energy, Water and Carbon in Peatland Ecosystems* Nigel Roulet, Invited	3-C-4.3 *An Albedo Parameterization for Sea Ice Models* Jan Sedlacek	3-C-5.3 *Comparison of the CMAM with Observation in the Mesosphere Region* Chao Fu
14:15	3-C-1.4 *Forecasting Fog by Coupling the 1D Boundary Layer Model COBEL with a Mesoscale Forecast Model* Stevie Roquelaure	3-C-2.4 *A Multi-Scale Air Quality Model with Applications for Policy and Forecasting: CHRONOS* Janusz Pudykiewicz, Invited		3-C-4.4 *Numerical Simulations of the Circulation in the Canadian Arctic Archipelago* Nicolai Kliem	3-C-5.4 *Equinox Transition in Airglow and Wind Observations* Gordon Shepherd
14:30	3-C-1.5 *Doppler Radar-based Precipitation Estimates over Southern Ontario during the Spring/Summer of 2000* Paul Ford	3-C-2.5 *Effects of an Improved Gas Dry Deposition Formulation in Reducing CHRONOS Model Error* Alain Robichaud	3-C-3.5 *A Vertical Diffusion Scheme to Estimate the Atmospheric Rectifier Effect* Baozhang Chen	3-C-4.5 *Arctic Polynyas and Climate Change Experiences from the NOW and CASES research networks* David Barber	3-C-5.5 *Multi-year Tidal Trends in Mesospheric Atomic Oxygen Profiles Derived from Remote Sensing of the Nightglow* Jason Russell
14:45	3-C-1.6 *From mm to cm...; A Study of Snow/Liquid Ratios over Quebec* Ivan Dubé	3-C-2.6 *Quantitative Sampling of Ambient Aerosols at Egbert, Ontario Using AerodyneAerosol Mass Spectrometer* Maheswar Rupakheti	3-C-3.6 *Energy Storage in a Highly-developed Urban Environment* Sarah Roberts	3-C-4.6 *Are Polynyas Self-sustaining?* R. Marsden	3-C-5.6 *Non-migrating Tides in the Extended Canadian Middle Atmosphere Model* William Ward
15:00	3-C-1.7 Operational Post Processed NWP Products: TAFtime and Thermobot		3-C-3.7 *Measuring Longwave Radiative Flux Divergence in an Urban*	3-C-4.7 *Surface Cloud Radiative Forcing in an Arctic Polynya*	3-C-5.7 *Closing Remarks*

	Bruno Larochelle		*Canyon* Andres Soux	Erica Key	
15:15 – 15:45	Health Break / Pause santé				
Room Salle	**Joliet/Frontenac (Conference Level)**	**Panorama (Penthouse Level)**	**Chaudière (Conference Level)**	**Pinnacle (Penthouse Level)**	**Richelieu (Conference Level)**
15:45 – 17:45	**3-D-1** **Operational Meteorology 3 : Processes / Météorologie opérationnelle 3 : Processus** Chair / Président : Mike Leduc	**3-D-2** **Chemical Meteorology and Air Quality 3 Météorologie chimique et Qualité de l'air 3** Chair / Président : Ann McMillan	**3-D-3** **Boundary Layer 2 : Simulation and Observation / Couche limite 2 : simulation et observation** Chair / Président : Peter Bartello	**3-D-4** **Arctic Oceanography and Meteorology 2 / Océanographie et météorologie arctique 2** Chair / Président : David Barber	**3-D-5** **Geophysical Fluid Dynamics / Dynamique des fluides géophysiques** Chair / Président : Peter Taylor
15:45	3-D-1.1 *Thunder Down Under: A Tornadic Supercell in Sydney, Australia, and the Role of Low-level Boundaries* David Sills	3-D-2.1 *Emission Inventory Data Preparation for Air-Quality Modelling* Trevor Scholtz, Invited	3-D-3.1 *Concentration Fluctuations in Dispersion Through Obstacle Arrays* Jayson Innes	3-D-4.1 *MSC's Action-plan 2000 (AP2000): Meeting Canada's Global Climate Observing Requirements North of 60* John MacPhee	3-D-5.1 *Moist Component Potential Vorticity* Ron McTaggart-Cowan
16:00	3-D-1.2 *On the Role of Drylines for Triggering Tornadic Storms in Alberta* Max Dupilka	3-D-2.2 *START - An Atmospheric Transport Analysis Tool* Julie Dion, Invited	3-D-3.2 *Fast First-order Wet Turbulence Model* Kyle Spyksma	3-D-4.2 *Evaluation of the Direct and Indirect Radiative Effect of Aerosols over the Western Arctic* Rong-Ming Hu	3-D-5.2 *Energetics of a Symmetric Circulation with Momentum Constraints* Sorin Codoban
16:15	3-D-1.3 *Downstream Weather Impacts Associated with Atmospheric Blocking: Linkage Between Low-frequency Variability and Weather Extremes* Marco Carrera	3-D-2.3 *Back Trajectory Analysis of PM2.5 and Ozone Behaviour in Southwestern Ontario* Carrie Lillyman, Invited	3-D-3.3 *COBEL Column Model Simulations of West Coast Marine Stratus* Peter Zwack	3-D-4.3 *NCEP/NCAR Reanalysis Surface u and v Field Sensitivity to Northern Hemisphere Annular Modes in the Circum-Polar Region* David Atkinson	3-D-5.3 *Dynamical Sensitivity of an Eastern North Pacific Cyclone to Downstream Development* Rick Danielson
16:30	3-D-1.4 *Small Scale Asymmetries in a Landfalling Hurricane* Yongsheng Chen	3-D-2.4 *Multi-episode Simulations of Ground-level PM and Ozone with AURAMS* Véronque Bouchet	3-D-3.4 *Boundary Layer Processes and Severe Alberta Thunderstorms* Geoff Strong	3-D-4.4 *Dynamical Feedback Associated to Aerosol Radiative Forcing in the Arctic During Winter* R. Munoz-Alpizar	3-D-5.4 *Zonal Flow Impacting an Isolated Island in the Equatorial Pacific* Ramzi Mirshak
16:45	3-D-1.5 *A Comparison Between Eastern North American and Western*	3-D-2.5 *High Resolution Modeling of Lake Breeze and Its Effect on Air*	3-D-3.5 *Decoupling of the Strongly Stable Atmospheric Boundary*	3-D-4.5 *Implementation and Validation of a New 2-moment Microphysics*	3-D-5.5 *The Theoretical Relationship between Double Kelvin Waves and*

	European Fronts Olivier Fortin	*Quality* Zhuming Ying	*Layer over an Antarctic Ice* Shelf Vicky Hipkin	*Scheme into the Single-column Model of the Northern Aerosol Regional Climate Model* L. Craciun	*Continental Shelf Waves And Suggestions of DKW Generation over the Labrador Shelf* Zhigang Xu
17:00	3-D-1.6 *Local Initiation of Deep Convection on the Canadian Prairie Provinces* John Hanesiak	3-D-2.6 *Air Quality Prediction and Health: An Alternative Air Quality Index Formulation* David Stieb, Invited	3-D-3.6 *ELBOW 2001: The Detection of Lake Breeze Fronts using a Variety of Observational Platforms* David Sills	3-D-4.6 *A 6-year Meteorological Record from a High Arctic Glacier: Implications for Mass Balance* Sarah Boon	3-D-5.6 *Simple Frontal Models of Baroclinic Instability* Mateusz Reszka
17:15	3-D-1.7 *A Reanalysis of Hurricane Hazel (1954)* Scott Weese	3-D-2.7 *The Future of Air Quality Prediction in Canada* Gordon McBean, Invited	3-D-3.7 *A Comparative Case Study of Lake Breeze Convective Precursors during ELBOW 2001* Bernard Firanski	3-D-4.7 *Régionalisation de l'Arctique par rapport à la dynamique du climat* J. Litynski	3-D-5.7 *Kalman Filter Data Assimilation and Balanced Dynamics* Lisa Neef
17:30					3-D-5.8 *The Impact of Diabatic Heating Structures and Model Resolution on Balanced-state Adjustments and Numerical Model Spin-up in an Idealized Numerical Simulation* Annie Duhamel
17:45					3-D-5.9 *Internal Wave Excitation by Thunderstorm Outflows* Morris Flynn
17:30 – 18:30	Poster Session B/ Session d'affiches B				
19:30	Banquet (Cocktails 18:30)				

SESSION 4-A Plenary / Plénière : Room / Salle Ballrooms B & C		Chair / Président : Paris Vachon
8:30	Invited / Invité 4-A-1 **Space Technologies, Global Monitoring of the Natural Environments: Canada's Role**	**Bjarni Tryggvason**
9:00	Invited / Invité 4-A-2 - ***Water in a Cold Climate: the Mackenzie GEWEX Story***	**Ming-ko Woo**
9:30	President's Prize Winner / Gagnante de le Prix du Président	**TBA**
10:00 – 10:30	Health Break / Pause santé	

Room Salle	**Richelieu (Conference Level)**	**Panorama (Penthouse Level)**	**Pinnacle (Penthouse Level)**	**Joliet/Frontenac (Conference Level)**
10:30 – 12:30	**4-B-1** **Remote Sensing 1 : Radar Meteorology and Precipitation / Télédétection 1 : Météorologie radar et précipitation** Chair / Président : Peter Zwack	**4-B-2** **Canadian Society of Agrometeorology 1 / Société canadienne d'agrométéorologie 1** Chair / Président : Paul Bartlett	**4-B-3** **Mackenzie GEWEX Study / Étude GEWEX Mackenzie** Chair / Président : Murray Mackay	**4-B-4** **Operational Oceanography / Océanographie opérationnelle** Chair / Président : Doug Bancroft
10:30	4-B-1.1 *The National Radar Project - Update and Status* Paul Joe	4-B-2.1, 2 *The Fluxnet Canada Research Network* Hank Margolis, Invited	4-B-3.1 *Trajectories of Atmspheric Moisture for a Heavy Rainfall Event over the MacKenzie River Basin* Julian Brimelow	4-B-4.1, 2 *Argo - The Global Profiling Float Array* Howard Freeland, Invited
10:45	4-B-1.2 *Error Statistics of VPR Corrections in Stratiform Precipitation* Aldo Bellon		4-B-3.2 *Radiation Budgets in the Mackenzie River Basin: An Evaluation of the Canadian Regional Climate Model* Jian Feng	
11:00	4-B-1.3 *Summary of Refractivity Observations by Radar during IHOP_2002* Frédéric Fabry	4-B-2.3 *Interannual Variability in the Carbon and Water Balances of a Boreal Aspen Forest in Central Saskatchewan, 1994 to 2002* Alan Barr	4-B-3.3 *An Assessment of Two Land Surface Schemes under Subarctic Tundra Conditions* Lei Wen	4-B-4.3 *On-going Applications in Operational Oceanography for the Gulf and Estuary of St. Lawrence* Denis Lefaivre
11:15	4-B-1.4 *Errors in the Radar Calibration by Gage, Disdrometer, and Polarimetry: Theoretical Limit and Application to Operational Radar* GyuWon Lee	4-B-2.4 *Measuring Respiration in a Coastal Douglas-fir Chronosequence* E. Humphreys	4-B-3.4 *Snow, Sublimation, Canopies and CLASS* Mark Gordon	4-B-4.4 *Real-time Forecasting of Total Water Levels Along the East Coast Of Canada* Keith Thompson
11:30	4-B-1.5 *A Radar-based Methodology for Preparing a Severe Thunderstorm Climatology in Central Alberta* Julian Brimelow	4-B-2.5 *Aggregating Surface Properties in the Canadian Boreal Forest* Paul Bartlett	4-B-3.5 *Using the Special Sensor Microwave Imager to Estimate a Soil Wetness Index for the Mackenzie River Basin* Marouane Temimi	4-B-4.5 *A POM-based Forecast Ocean Modelling System for the Northeast Pacific* Scott Tinis

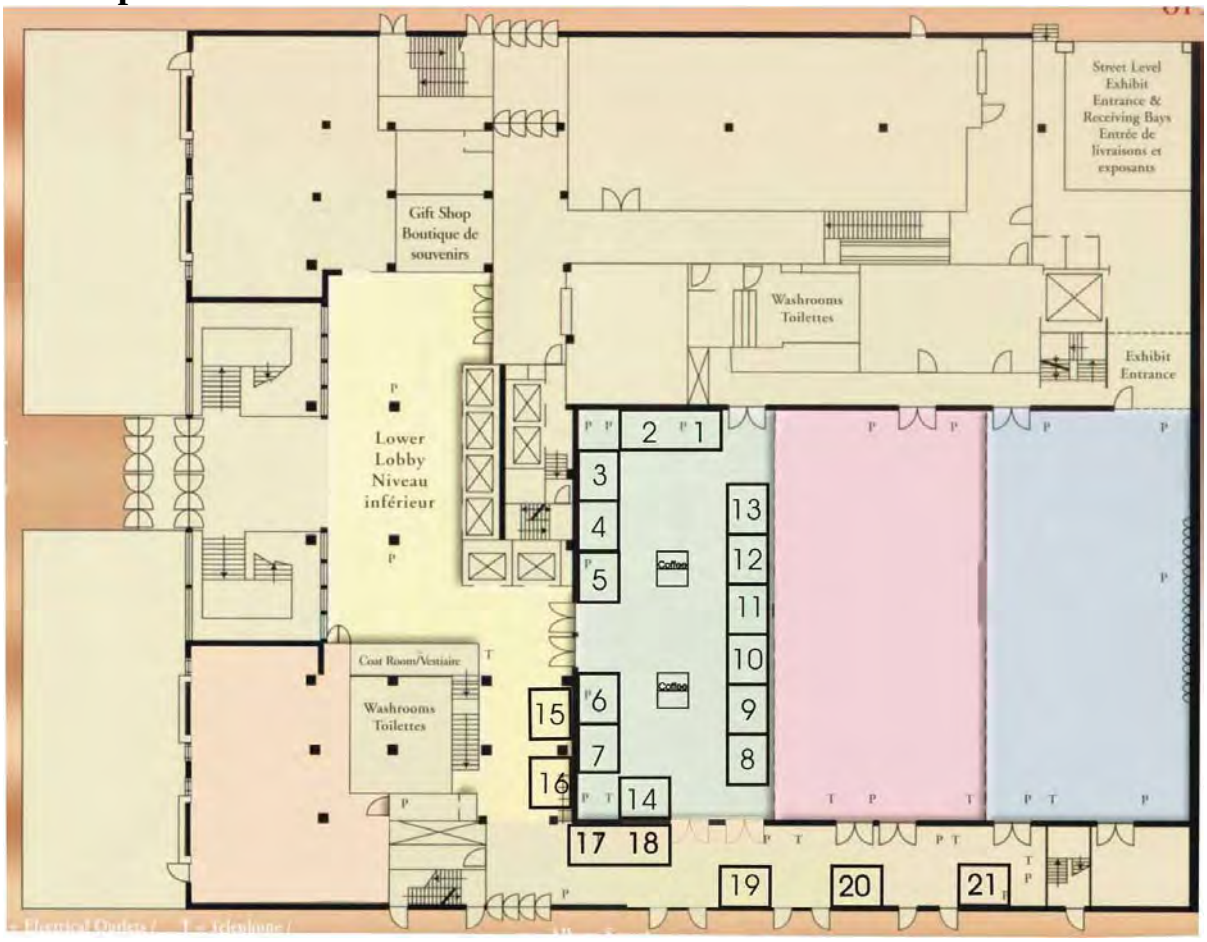
11:45	4-B-1.6 *Detection and Monitoring of Precipitation from Space using Spaceborne Passive Microwave Observations* Irene Rubinstein	4-B-2.6 *Tropospheric Ozone in the Forests of the Lower Fraser Valley, British Columbia and the Threat of Injury to Forest Plants* Judi Krzyzanowski	4-B-3.6 *Using Climate Station and Gridded Data for Modelling Daily Streamflow of a Large Mountainous Catchment* Robin Thorne	4-B-4.6 *Modelling Tsunami-generated Currents in Canadian West Coast Harbours* William Crawford
12:00	4-B-1.7 *Comparison of Precipitable Water Over Canada Obtained From Ground-based GPS, Radiosondes, and the Canadian Global Analysis System* Godelieve Deblonde	4-B-2.7 *Poster Precis*	4-B-3.7 *Development and Evaluation of the Distributed Hydrologic Model WATCLASS for the Mackenzie Basin GEWEX Study* Jonathan Bastien	4-B-4.7 *Assimilation of Lagrangian Data Using the Ensemble Kalman Filter: Idealized Experiments Based on an Idealized Vortex System* Kassiem Jacobs
12:15 – 13:30	Lunch / Dîner Poster Session C/ Session d'affiches C			
Room Salle	**Ballroom B** **(Lower Level)**	**Panorama** **(Penthouse Level)**	**Ballroom C** **(Lower Level)**	**Pinnacle** **(Penthouse Level)**
13:30 – 15:15	**4-C-1** **Remote Sensing 2 : Coastal Zones and Oceans / Télédétection 2 : Zones côtières et océans** Chair / Président : Jim Helbig	**4-C-2** **Canadian Society of Agrometeorology 2 / Société canadienne d'agrométéorologie 2** Chair / Président : Jon Warland	**4-C-3** **Operational Meteorology 4 : Performance Measurement II / Météorologie opérationnelle 4 : Mesures de la performance II** Chair / Président : Jim Abraham	**4-C-4** **Coastal Oceanography 1 / Océanographie côtière 1** Chair / Président : Guoqi Han
13:30	4-C-1.1 *Integrating SONAR, LIDAR, GPS and CASI on Prince Edward Island: Towards a Seamless Coastal DEM* Gavin Manson	4-C-2.1, 2 *Interesting Measurements Obtained using the NRC Twin Otter Research Aircraft* Raymond Desjardins, Invited	4-C-3.1, 2 *Verification of Spatial/Gridded Forecasts* Barbara Brown, Invited	4-C-4.1, 2 *Data Assimilation with Representers: An Example for the Waters around Vancouver Island* Mike Foreman, Invited
13:45	4-C-1.2 *High Frequency Surface Wave Radar Operating in Regions of Shallow Water* Eric Gill			
14:00	4-C-1.3 *Ocean Environmental Conditions from 3.0-5.0 MHz HFSWR* Michael Henschel	4-C-2.3 *Greenhouse Gas Emissions in Barley Fields as Affected by Tillage and Soil Texture* Philippe Rochette	4-C-3.3 *Recent Trends in Skill of Weather Element Forecasts in Canada* Richard Verret	4-C-4.3 *Circulation over the Newfoundland and Labrador Shelf: A modeling study* Guoqi Han
14:15	4-C-1.4 *Comparison of Ocean Gravity Wave Spectra Measured with Surface Wave Buoys, Acoustic Doppler Current Profilers and Space-based Synthetic Aperture Radar* Daniel Hutt	4-C-2.4 *Measuring Greenhouse Gas Emissions at the Farm-Scale Using the Nocturnal Boundary Layer Budget Method* Laura Wittebol	4-C-3.4 *Verification of Precipitation Forecasts at High Resolution* Laurence Wilson	4-C-4.4 *Tidal and Flooding Modelling of the Bay of Fundy* Frédéric Dupont

14:30	4-C-1.5 *An Examination of the Physical and Optical Properties of Melt Ponds on Landfast First Year Sea Ice* Robert Kirk	4-C-2.5 *Methane Emission from Beef Cattle on Different Diets* Sean McGinn	4-C-3.5 *Public Weather Forecast Performance Measurement Project (PWFPM)* Pierre Pommainville	4-C-4.5 *Currents and Mixing in a Tidally Energetic Inlet* Michael Stacey
14:45	4-C-1.6 *Geodetically Referenced Sea Surface Topography over the Scotian Shelf from Satellite Altimetry* Guoqi Han	4-C-2.6 *The Greenhouse Gas Emissions from Stored Swine Liquid Manure* Kyu-Hyun Park	4-C-3.6 *Assessment of the Economic Value of Forecasts* Laurence Wilson	4-C-4.6 *A New Two-way Nesting Technique Based on the Semi-prognostic Method* Jinyu Sheng
15:00	4-C-1.7 *Estimation of Sea Surface Temperature with Passive Microwave Radiometry from the DMSP Satellites* Joseph Buckley	4-C-2.7 *Laboratory Scale Measurements of Nitrous Oxide and Methane Emissions from a Hybrid Poplar: (Populus deltoides x Populus nigra (DN-2 Clone))* M. McBain	4-C-3.7 *Delivery of Weather and Weather-related Services and Public Good* Gordon McBean	4-C-4.7 *Improving Coarse Resolution Ocean Models* Daniel Wright
15:15 – 15:45	Health Break / Pause santé			
Room Salle	**Ballroom B** **(Lower Level)**	**Panorama** **(Penthouse Level)**	**Ballroom C** **(Lower Level)**	**Pinnacle** **(Penthouse Level)**
15:45 – 17:30	**4-D-1** **Remote Sensing 3 : Atmosphere / Télédétection 3 : atmosphère** Chair / Président : Paris Vachon	**4-D-2** **Canadian Society of Agrometeorology 3 / Société canadienne d'agrométéorologie 3** Chair / Président : Jon Warland	**4-D-3** **Operational Meteorology 5 : MSC Update / Météorologie opérationnelle 5 : nouvelles du SMC** Chair / Président : Fred Conway	**4-D-4** **Coastal Oceanography 2 / Océanographie côtière 2** Chair / Président : Guoqi Han
15:45	4-D-1.1 *Monitoring the Global Energy Budget and Hydrologic Cycle with TRMM and the Afternoon "A-Train"* Tristan L'Ecuyer	4-D-2.1 *A Multi-layer Model Incorporating Lagrangian Dispersion to Address the Relationship Between Leaf and Canopy Resistance* Adriana Furon	4-D-3.1, 2 *MSC - Focusing for the Future* Marc Denis Everell, Invited	4-D-4.1 *Update on the Lunenburg Bay Project* Serge Desjardins
16:00	4-D-1.2 *Comparison of Radiosonde and Radiometer Measurements with Global Environmental Multiscale (GEM) and Rapid Update Cycle (RUC) Models During the AIRS 1.5 Project* Ziatko Vukovic	4-D-2.2 *The Application of Airborne Pollen Dispersal Modeling to Regulatory Risk Assessment for Genetically Engineered Plants* Franco Di-Giovanni		4-D-4.2 A *Three-Dimensional Coastal Circulation Model for Lunenburg Bay, Nova Scotia* Liang Wang

16:15	4-D-1.3 *The Measurements Of Pollution In The Troposphere (MOPITT) Instrument: 40 Months of Carbon Monoxide Measurements* James Drummond	4-D-2.3-7 *CSAM AGM* CSAM	4-D-3.3 *Data Management Framework for The Meteorological Service of Canada (MSC) Operational Monitoring Networks* Michael Minuk	4-D-4.3 *Variable Resolution Near Shore Circulation Modelling in the Bay of Fundy* David Greenberg
16:30	4-D-1.4 *Assessment of CO Emission from Biomass Burning in Canada and USA Based on MOPITT Data* Jane Liu		4-D-3.4 *A Status Report on the Reference Climate Station and the Surface Weather Networks* Yves Durocher	4-D-4.4 *Sustainable Development Issues Facing Finfish Aquaculture in the Bay of Fundy - - Application of a Tidal Circulation Model* Fred Page
16:45	4-D-1.5 *Feasibility of Monitoring Atmospheric Carbon Dioxide Columns from a Nadir View Fourier-Transform Infrared Spectrometer* Dmitry Yashcov		4-D-3.5 *Development of the Canadian Aircraft Meteorological Data Relay (AMDAR) Program - An Update* Gilles Fournier	4-D-4.5 *Current and Hydrographic Variability on the Scotian Slope, 2000-2002* Yuri Geshelin
17:00	4-D-1.6 *The MAESTRO Instrument on SciSat-1: One Component of the Atmospheric Chemistry Experiment* Thomas McElroy		4-D-3.6 *Current Status and Future Improvements in the Canadian Meteorological Center's Analysis and Forecasting System* Yves Pelletier	4-D-4.6 *A Seventy-year Record of Dwindling Deep-water Oxygen Levels in the Lower St. Lawrence Estuary* Denis Gilbert
17:15	4-D-1.7 *Realistic Detailed Model Generated Cloud Scences for Earthcare* Alain Beaulne		4-D-3.7 *New CMC Products - GRIB data and Other Products / Nouveaux Produits du CMC - Données GRIB et Autres Produits* Lewis Poulin	4-D-4.7 *Influence of the Surface Horizontal Wind on the Circulation of the Gaspé Current as Simulated by the Canadian Regional Climate Model (CRCM) and the Gulf of Saint-Lawrence Ocean Model (GOM)* Dorethée Charpentier

Exhibitors / Exposants

Lower Level / Niveau inférieur



Booth/Stand	Exhibitor/Exposant
1	Canadian Ice Service, MSC / Service canadien des glaces, SMC
2	Meteorological Service of Canada / Service météorologique du Canada
3	DASCO Equipment Inc.
4	Vaisala Inc.
5	Campbell Scientific Inc.
6	Radarsat International
7	Canadian Space Agency / Agence spatiale canadienne
8	COMET / UCAR
9	Marine Environmental Data Service (MEDS), DFO / SDMM MPO
10	Government of Canada Climate Change / Changements climatiques - Gouvernement du Canada
11	Noetix Research Inc.
12	Climate Change Impact and Adaptation Research Network (C-CIARN)
13	Hoskin Scientific Ltd.
14	Weather Network / Météomedia
15	Canadian Foundation for Climate and Atmospheric Sciences (CFCAS) / FCSCA
16	CMOS
17	Radiometrics Corporation & Weather Decision Technologies
18	Info-Electronics Systems Inc. / Systèmes Info-Électroniques Inc.
19	Richard Brancker Research
20	U.S. National Ice Center
21	Canadian Centre for Remote Sensing - NRCan

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Il a pour mandat de gérer et de conserver en archives les données océaniques recueillies par le MPO ou obtenues dans le cadre de programmes de recherche nationaux et internationaux exécutés dans des zones océaniques situées à proximité du Canada, de diffuser des données et d'offrir des produits de données et des services à la collectivité marine en respectant les politiques du Ministère.

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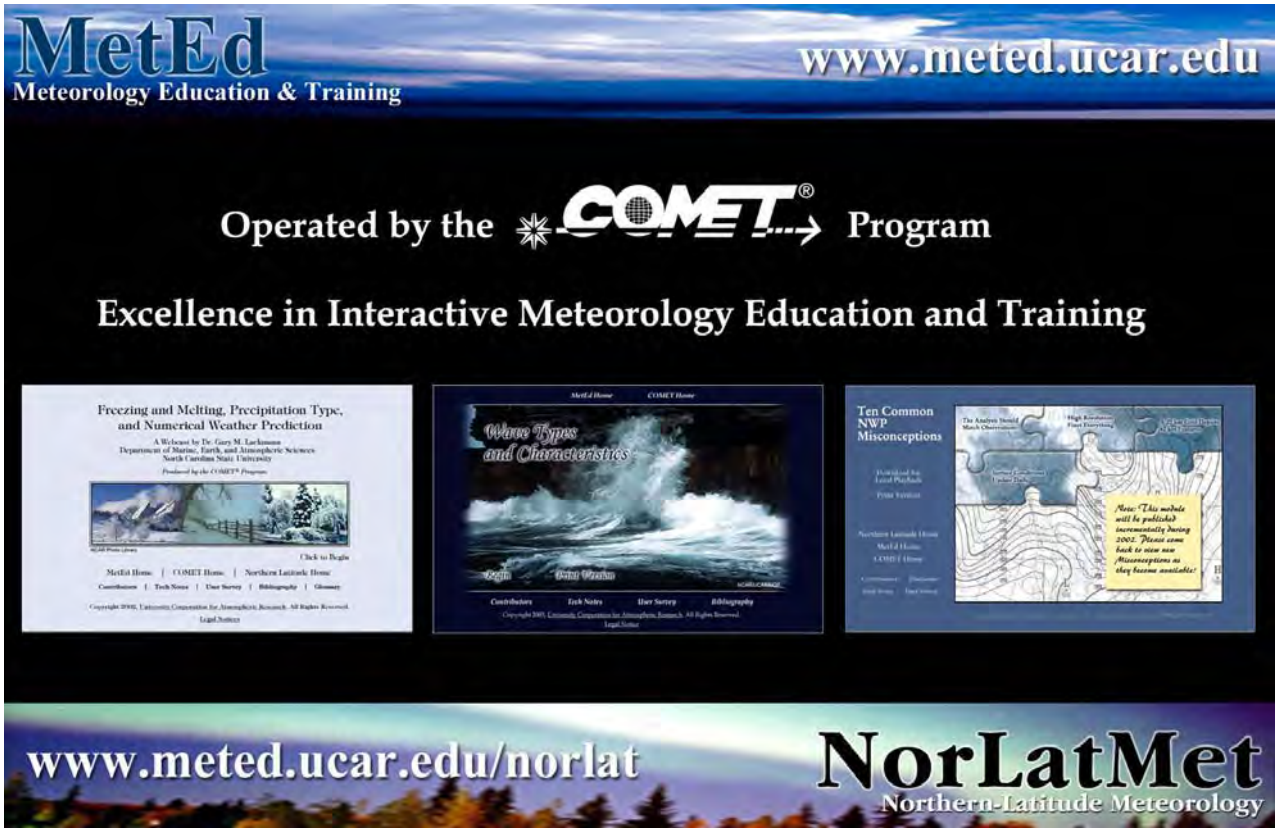

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Government of Canada - Climate Change Action Fund-Public Education and Outreach (CCAF-PEO)

The Government of Canada released the Climate Change Plan for Canada in November 2002. The Plan is the result of intensive consultation with the provinces and territories, as well as with stakeholders and individual Canadians and reflects the Government of Canada's commitment to action on climate change while ensuring our economic competitiveness and growth.

The Plan challenges every Canadian to reduce his or her individual greenhouse gas emissions by one tonne, or 20%. Come to our booth to try a climate change quiz and find out how you can reach the one tonne goal. Win a free climate change magnet with a built-in thermometer!

Gouvernement du Canada – Fonds d'action pour le changement climatique – Sensibilisation du public (FACC-SP)

Le gouvernement du Canada a publié le Plan du Canada sur les changements climatiques en novembre 2002. Ce plan est le résultat de consultations intensives avec les provinces et les territoires ainsi qu'avec les intervenants et la population canadienne, et témoigne de la volonté du gouvernement du Canada d'intervenir pour lutter contre les changements climatiques tout en assurant notre compétitivité et notre croissance économique.

Le Plan met au défi chaque Canadien de réduire ses émissions de gaz à effet de serre d'une tonne ou de 20 %. Rendez-vous à notre stand pour répondre à un questionnaire sur les changements climatiques et découvrir comment vous pouvez atteindre le but de réduction d'une tonne. Gagnez un aimant des changements climatiques avec thermomètre intégré!

C-CIARN Canadian Climate Impacts and Adaptation Research Network
Réseau canadien de recherche sur les impacts climatiques et l'adaptation

The Canadian Climate Impacts and Adaptation Research Network is comprised of six Regions and seven national Sectors connecting researchers and stakeholders across the country. The national, regional and sectoral C-CIARN offices are building a network
of researchers and stakeholders, facilitating research and helping to provide voice and visibility to climate change impact and adaptation issues. C-CIARN Regions are British Columbia, Prairies, Ontario, Quebec, Atlantic and the North. C-CIARN Sectors are Water Resources, Forest, Agriculture, Fisheries, Landscape Hazards, Coastal Zone and Health.

www.C-CIARN.ca

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Le Réseau canadien de recherche sur les impacts climatiques et l'adaptation est constitué de six régions et sept secteurs nationaux reliant les scientifiques et les partenaires à travers le pays. Les bureaux national, régionaux et sectoriels du C-CIARN monteront un réseau de chercheurs et d'intervenants, faciliteront la recherche et aideront à faire connaître les impacts du changement climatique et les options qui existent en matière d'adaptation. Les regions de C-CIARN comprennent la Colombie-Britannique, les Prairies, l'Ontario, le Québec, l'Atlantique, et les Territoires du Nord. Les secteurs de C-CIARN sont: les Ressources hydriques, Forestier, l'Agriculture, les Pêches, les Dangers pour les paysages, les Zones côtières, et la Santé.

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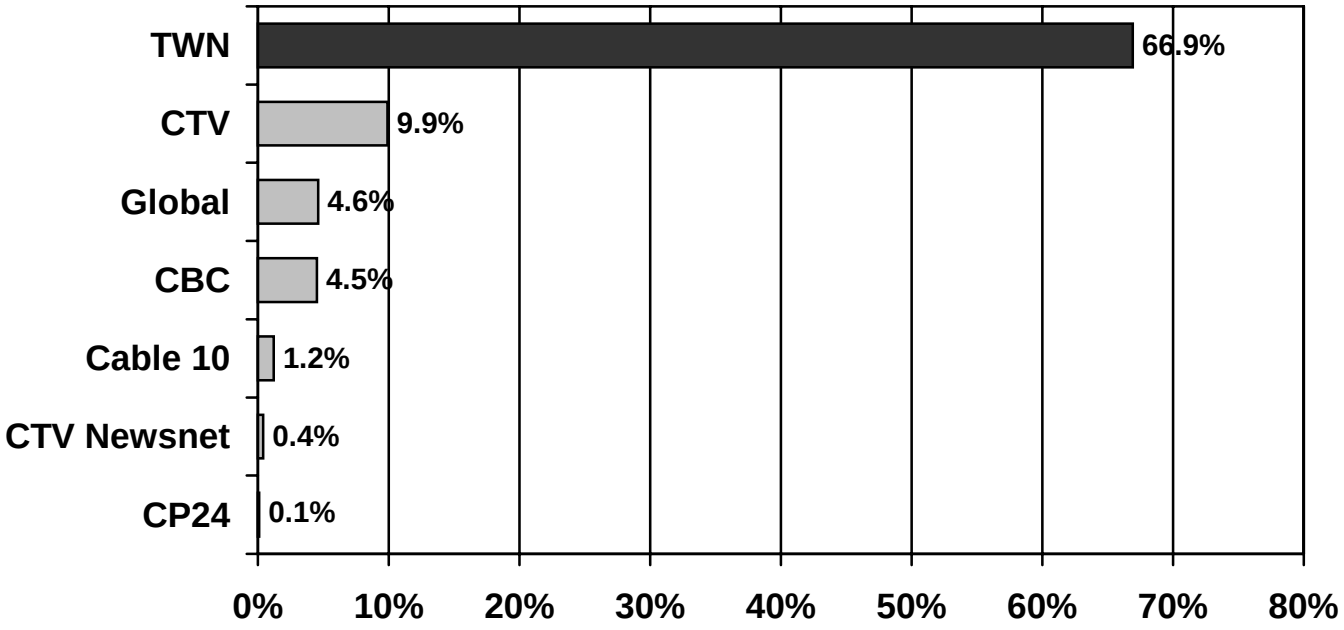

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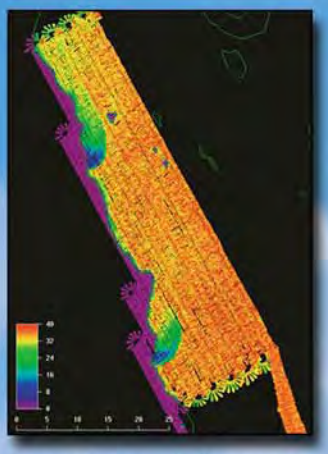

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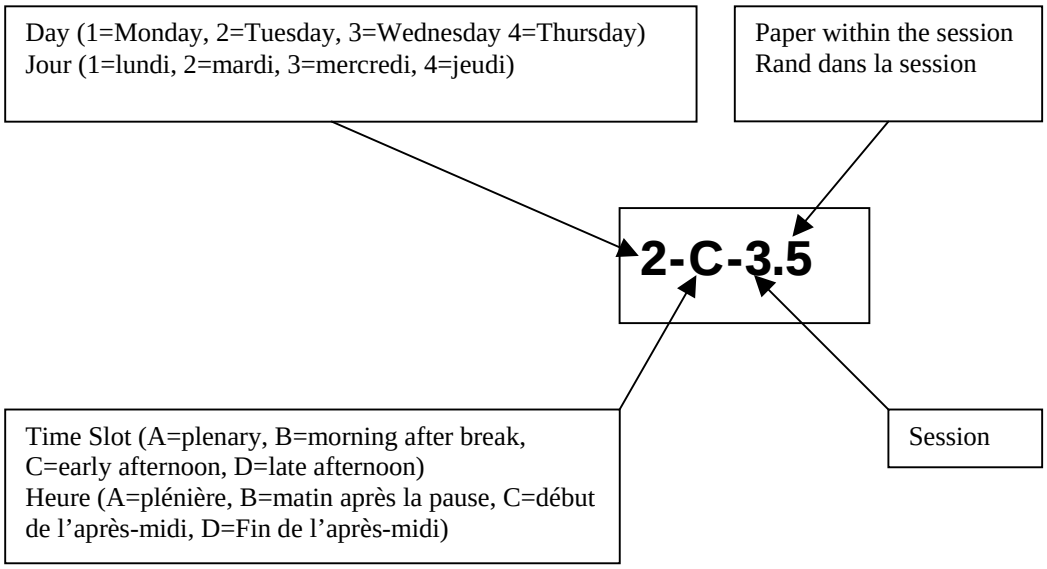

Abstract Coding explanation

Explication des codes des résumés

Session 1-A

Plenary / Plenière

Chair / Président
Charles Lin

Monday 2 June 2003
lundi 2 juin 2003

Room / Salle
Ballroom B & C

1-A-1
Monitoring Climate Change and Variations: Progress and Challenges
Tom Karl
US National Climatic Data Center

In the process of delivering the past several international assessments of climate change the climate community has struggled to provide reliable information about observed climate changes and variations. This includes changes on both regional and global scales with accurate confidence intervals. There are a number of historical reasons for this, and they will be discussed at some length. However, there are now some encouraging signs that suggest that progress in this area could be greatly accelerated over the next decade. This includes:

- new observing system technologies,
- a better recognition of the requirements for monitoring decadal and longer term climate variations and changes into existing networks including integration of observing systems,
- a growing recognition of the importance of linking existing extreme weather and climate events to natural or human induced causes, and
- maturity of the principles of climate monitoring for both in-situ and satellite observing systems.

Several examples will be discussed to support this notion, including collaborative work in North America to monitor extreme weather and climate events in a historical context in near-real time.

1-A-2
Sharing Science with the Public at a National Research Laboratory
R. M. Johnson
Office of Education and Outreach, University Corporation for Atmospheric Research

The growing consensus that improving science education and public science literacy requires the focused efforts of a wide spectrum of specialists, including scientists, provides the opportunity for national research centers to develop programs that seek to uniquely bring their science to educators and the public. At the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, we have developed a multifaceted program for science education and outreach designed to bring our science to these audiences in a way that builds on our specialized expertise. Education and outreach activities at NCAR include numerous opportunities to engage with the public in informal settings as well as programs targeting the formal education system. Our exhibit and tour program offers topically focused interactive activities and opportunities to learn about the science underway at the laboratory. We also hold annual events open to the public, providing high energy science demonstrations and lectures for the public. Our web sites provide extensive resources for students, educators, and the public to learn on their own about our science, supplemented by interactives and hands-on activities. Professional development workshops for K-12 educators provide background on science content as well as training on inquiry-based hands-on and computer based activities that enrich and deepen the learning experience for students. We also seek to attract students to graduate study in atmospheric and related sciences through opportunities to interact with scientists at the laboratory, learn about state-of-the-art atmospheric research, and consider concepts of leadership in science. Central to all of these education activities is the active participation of lab scientists and staff, whose personal enthusiasm and science expertise enriches the program.

1-B-1.1
GEWEX and the Water Cycle
Ronald E. Stewart
Department of Atmospheric & Oceanographic Sciences, McGill University

The water cycle is of utmost importance to climate and weather as well as to life in general. Realizing this, some 15 years ago the World Climate Research Programme initiated a research program to observe, model and predict the water cycle as well as to improve the application of this research. This program is referred to as the Global Energy and Water Cycle Experiment (GEWEX). To address its goals, GEWEX has determined the water cycle through satellite and surface based measurements, it has improved the representation of many processes associated with the water cycle in the atmosphere and surface, it has initiated a number of experiments to examine regional water cycle issues (including the Mackenzie GEWEX Study), it has worked with other programs to improve prediction of water cycle related variables, and it has engaged the water resource community to apply the ongoing research. In this presentation, the goals of GEWEX, some of its scientific accomplishments and some of its future plans will be briefly summarized.

1-B-1.2
A Technique to Detect Microclimatic Inhomogeneities in Historical Temperature Records
K. E. Runnalls and T. R. Oke
Department of Geography, University of British Columbia, Vancouver

A technique to identify inhomogeneities in historical temperature records caused by microclimatic changes to the surroundings of a climate station (e. g. minor instrument relocations, vegetation growth/removal, construction of houses, roads, runways) is presented. The technique uses daily maximum and minimum temperatures to estimate the magnitude of nocturnal cooling. The test station is compared to a nearby reference station by constructing time series of monthly 'cooling ratios'. It is argued that the cooling ratio is a particularly sensitive measure of microclimatic differences between neighbouring climate stations. Firstly, because microclimatic character is best expressed at night in stable conditions. Secondly, because larger-scale climatic influences common to both stations are removed by the use of a ratio and, because the ratio can be shown to be invariant in the mean with weather variables such as wind and cloud. Inflections (change points) in time series of cooling ratios therefore signal microclimatic change in one of the station records. Hurst rescaling is applied to the time series to aid in the identification of change points, which can then be compared to documented station history events, if sufficient metatdata is available. Results for a variety of air temperature records, ranging from rural to urban stations, are presented to illustrate the applicability of the technique.

1-B-1.3
Generic Homogeneity Test for Climate Time Series Data
Jean Gagnon
Marine Environmental Data Services Branch

Homogeneous climatic time series of environmental parameters are essential for studies of climatic fluctuations and changes. Abrupt discontinuities can occur over time due to changes in instrumentation, station relocations, and changes in calculation procedures for time-averaged values to name but a few reasons. The Standard Normal Homogeneity Test currently implemented for rainfall and air temperature networks can be applied generically to other networks of observed environmental parameters. This paper will demonstrate the usefulness of this test in identifying discontinuities in a network of water level measurements, independent of whether they are observed within a tidal or freshwater regime.

Session 1-B-1

Climate and Climate Change 1 / Le climat et le changement du climat 1

Chair / Président
Rob Cross

Monday 2 June 2003
lundi 2 juin 2003

Room / Salle
Joliet/Frontenac

Session 1-B-1

Climate and Climate Change 1 / Le climat et le changement du climat 1

Chair / Président
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Monday 2 June 2003
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1-B-1.4
Evaluation of Geographical Positioning Systems to Determine Diurnal Trends in Integrated Atmospheric Moisture
Craig D. Smith
Climate Research Branch, Meteorological Service of Canada

The use of Geographical Positioning System (GPS) technology for determining integrated atmospheric moisture is a relatively new application and has only recently been applied by Canadian researchers. One of the advantages of the GPS technique is the increased temporal resolution of the observations that, unlike radiosondes, can be produced in 30-minute intervals (or less). This increased resolution is advantageous for examining diurnal trends in integrated moisture associated with determining atmospheric moisture budgets. Diurnal trends are often missed entirely with conventional observations made only twice daily. GPS moisture retrieval techniques were tested in a northern environment over the course of 2000 with a GPS system co-located with the MSC operational radiosonde site at Ft. Smith, NT. Correlations between GPS derived and radiosonde measured integrated atmospheric water vapour were favorable with r-squared values of 0.96. Based on the twice-daily radiosonde comparisons, it was determined that there was an increase in the bias between the GPS and the radiosondes from the 1200 to 0000 UTC observation periods with the GPS observing less moisture than the radiosondes for both periods. The implications of this are significant for determining diurnal trends in atmospheric moisture using GPS systems. This phenomenon was further explored during a 10-day intensive field campaign in northern Saskatchewan that involved 75 radiosonde launches between July 2 and 12, 2002. The results of this campaign are presented.

1-B-1.5
Simplified Nonlinear Principal Component Analysis, With Applications to Climate Datasets
Beiwei Lu and William W. Hsieh.
Dept. of Earth & Ocean Sciences, University of British Columbia, Vancouver

Nonlinear principal component analysis (NLPCA) by autoassociate feedforward neural networks with 3 hidden layers of neurons has recently been applied to analyze a number of meteorological/oceanographic datasets. However, many of these datasets, especially climate datasets, tend to be relatively short and noisy. Under these conditions, NLPCA with its large number of parameters and great flexibility could easily lead to overfitting, i. e. fitting to noise in the dataset. We found that by trimming the NLPCA network from 3 to 2 hidden layers, and eliminating the bias parameters from the bottleneck and output layers, a simpler NLPCA model results, which greatly alleviates the overfitting problem and the non-uniqueness problem associated with the nonlinear principal component. This new model is applied to analyze several datasets-- the Lorenz (1963) chaotic system, the Pacific sea surface temperatures (containing the El Niño and Pacific Decadal Oscillation phenomena), and the equatorial stratospheric zonal winds (containing the Quasi-Biennial Oscillation phenomenon).

1-B-1.6
Simulation of Natural Millennial-Scale Climate Variability from the Early Holocene (8 Kyr Bp) to the Preindustrial Period (1700 Ad) using the McGill Paleoclimate Model
Yi Wang[1], Lawrence A. Mysak[1], Zhaomin Wang[1] and Victor Brovkin[2]
Centre for Climate and Global Change Research
and
[1]Department of Atmospheric and Oceanic Sciences, McGill University
[2]Potsdam Institute for Climate Impact Research, Potsdam, Germany

Multiple proxy data reveal that the middle Holocene (6 kyr BP) was warmer than the early Holocene (8 kyr BP) as well as the preindustrial period (1700 AD) in most regions of the Northern Hemisphere. This warmth is somewhat counterintuitive because the summer insolation was decreasing during this time. Cooling in the late Holocene (after 6 kyr BP) is hypothesized to be due mainly to the

astronomical forcing. This cooling was also accompanied by significant changes in vegetation cover (i. e., treeline retreat from northern high latitudes; the desertification of the Sahara/Sahel region) and a small but gradual increase of atmospheric CO_2 concentration (from 260 ppm to 280 ppm). The early-to-middle Holocene warming, on the other hand, is hypothesized to be due in part to ice-albedo feedback in Northern America, associated with decreases in the Laurentide ice sheet, which completely disappeared by 6 kyr BP. The snow-vegetation-albedo feedback is also hypothesized to have played a role in this early warming event. To test the above hypotheses, the earlier geophysical McGill Paleoclimate Model has been coupled to the vegetation model known as VECODE (VEgetation COntinuous DEscription, one of the simpler dynamic global vegetation models), and a number of sensitivity experiments have been performed. The model results illustrate the role that Northern Hemisphere land cover changes played in explaining the natural millennial-scale climate variability from the early Holocene (8 kyr BP) to the preindustrial period (1700 AD).

1-B-1.7,8
Ken Hare and Climate Research
Peter Adams
MP Peterbourogh

Ken Hare was involved in academic and public policy aspects of natural and artificial “climate change” before that concept became current. At McGill University, among many other things, (including the founding of the Department of Meteorology), he founded and built up the McGill Subarctic Research Laboratory in Schefferville, northern Quebec, and was a founder of the McGill Axel Heiberg Expeditions. The former was a university-run weather station, which was a base for training and research by resident students for twenty years. It continues today on the McGill Subarctic Research Station. The second, among many other things, initiated glacier research at 80 degrees North, a latitude which is of great interest nowadays as a part of the world where global warming is predicted to be most marked. Research on these glaciers continues today. In his later years, Ken was a two-term Chancellor of Trent University, where through teaching and example, he continued to influence climate research. Through his life, he took an active interest in the translation of the results of academic research into public policy at the provincial, federal and international levels.

Session 1-B-1

Climate and Climate Change 1 / Le climat et le changement du climat 1

Chair / Président
Rob Cross

Monday 2 June 2003
lundi 2 juin 2003

Room / Salle
Joliet/Frontenac

Session 1-B-2

Numerical Weather Prediction-COMM 1 / Prévision numérique du temps-COMM 1

Chair / Président
Stéphane Bélair

Monday 2 June 2003
lundi 2 juin 2003

Room / Salle
Pinnacle

1-B-2.1
COMM: Meteorological Model, Tools, Data And Support For Researchers, An Update.
Stéphane Chamberland

For a number of years, MSC/RPN has provided help to researchers in Universities and local forecast offices doing research in mesoscale meteorology by providing a full world class meteorological model (MC2/COMM) along with tools and data that support it. The MC2/COMM model, which is licenced as an open source distribution, has evolved rapidly with combined effort from the users (community) and MSC/RPN developers.
The model has improved greatly in the past year, solving long standing problems and improving its performance on scalar/distributed computers. Moreover, the MSC operational model (GEM) in its limited area version is now a reality and work is in progress to make it available as a COMM model. The present COMM model's improvements and a roadmap for the coming one will be described along with new tools.

1-B-2.2
The Evolution of Elliptic Solvers in MC2
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[2]University of British Columbia, Vancouver, BC

The elliptic problems in semi-implicit nonhydrostatic atmospheric models are difficult. Typically, they are poorly conditioned, nonseparable, contain cross derivative terms, and often are nonsymmetric due to boundary conditions. In MC2, the resulting linear system is solved using a preconditioned nonsymmetric Krylov iterative method.

A horizontal spectral preconditioner was recently developed as an alternative to a more-standard and much simpler line-Jacobi relaxation scheme. However, in the context of general curvilinear coordinates (e. g. the Gal-Chen and Sommerville 1975 transformation) the spectral preconditioner requires neglecting cross derivative terms and homogenization (e. g., averaging) metric coefficients over the computational domain. Because such a compromise causes a substantial departure of the preconditioner from the original elliptic operator, it is not obvious a priori whether it leads to a competitive solver.

In this talk, we evaluate the robustness of the proposed approach over a broad range of representative meteorological applications, in the context of a three-time-level semi-implicit semi-Lagrangian all scale weather-prediction/research model.

1-B-2.3
Finescale Orography and the MC2 Semi-Lagrangian Scheme
Claude Girard and Michel Desgagne
Recherche en Prevision Numerique (RPN), Environnement Canada

High sensitivity of the MC2 to finescale orography forcing was recently recognized as a genuine numerical problem. Since its creation, the model was typically run with highly filtered orography fields so the problem remained largely hidden or at least was kept under control. A canonical experiment involving small scale evanescent mountain waves is here used to illustrate the problem. A first study by Schar et al. (2002) proposes a modified vertical terrain-following coordinate to greatly diminish the MC2 sensitivity to very high resolution topography. This sensitivity was nevertheless definitely diagnosed to be of spurious nature and in fact due to numerical inconsistencies between second and third order accurate parts of the semi-Lagrangian scheme (Klemp et al. 2003). A clean solution to this problem was needed... and has been found.

1-B-2.4

High-Resolution Real-Time Numerical Weather Prediction and Verification of Near Shore Winds over Lake Ontario

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Meteorological Service of Canada, Burlington Ontario

Due to its small-scale nature and its proximity to the land-water boundary, the near shore wind field is highly variable both spatially and temporally. Additionally, its complexity is often increased due to the effects of local topography, thermally induced lake-land breeze effects and the dynamics associated with the superimposed synoptic scale pressure pattern. As a result, most operational numerical weather prediction (NWP) model outputs are too coarse to fully resolve the variability and complexity of low-level wind field in the near shore areas. A research project approved by the SAR New Initiative Fund (SAR EC3-01 NIFID 2001044) has been designed to improve near shore wind forecasts over the Great Lakes by means of developing a high-resolution mesoscale NWP low-level wind forecast system. An enhanced network of real-time data buoys and shore meteorological observing stations will be used to validate and verify the mesoscale model output.

After a brief overview of the research project, the real-time high-resolution mesoscale NWP system is introduced and its configuration described. Model simulations have been performed on several recent strong wind events over Lake Ontario in order to validate the prediction system. Diagnostic studies that have been done on the simulated model output from these recent events include: (1) comparison of the observed wind field with the low-level predicted wind fields from both the mesoscale NWP system and the operational Global Environmental Multiscale (GEM) model of the Meteorological Service of Canada (MSC), (2) verification of the mesoscale model in forecasting the occurrence of wind speeds exceeding the Small Craft Wind Warning criteria and Gale Warning criteria, (3) the capability of the mesoscale model to accurately predict the wind field under different synoptic weather regimes, and (4) examination of the suitability of a proposed index for verification of wind forecasting. These diagnoses will be beneficial to evaluate the accuracy in computing heat and moisture fluxes at the air-lake interface, and topographically induced vertical motion.

1-B-2.5

Integrating an Urban Parameterization with MC2 to Simulate Low-Level Urban Temperature Distributions

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Replacement of natural surfaces with urban structures and associated materials alters near-surface climates. Mesoscale models are commonly used in studies of urban climates because they resolve atmospheric processes over urban areas from the synoptic scale down to the local scale. However, many microscale phenomena, such as urban canopy layer (UCL) interactions, must be parameterized. Traditional solutions to this problem involve the modification of roughness, moisture, thermal and radiative parameters in soil-vegetation-atmosphere transfer (SVAT) schemes to urban values (i. e. the "slab" approach). However, this approach does not explicitly account for the geometry of the urban surface (e. g. the urban canyon) or the associated radiative and thermal interactions. Several UCL parameterizations for mesoscale models have been developed in recent years to fill this gap. A modified version of the Martilli et al. (2002) urban parameterization is combined with the Interactive Soil-Biosphere-Atmosphere (ISBA) (Noilhan and Planton 1989) SVAT scheme to provide surface boundary conditions to the Mesoscale Community Compressible (MC2) model. Model performance in replicating low-level urban air temperature transect observations during August 1997 is reasonable. Impacts of urban heat mitigation strategies, such as increased roof albedo, are found to be less significant than in previous modeling efforts.

Session 1-B-2

Numerical Weather Prediction-COMM 1 / Prévision numérique du temps-COMM 1

Chair / Président
Stéphane Bélair

Monday 2 June 2003
lundi 2 juin 2003

Room / Salle
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1-B-2.6
Limited Area Modelling with GEMDM
Michel Desgagne and Vivian Lee
Recherche en Prevision Numerique (RPN), Environnement Canada

As an alternative for variable resolution grids used for high resolution simulations with the GEMDM model, a Limited Area Model (LAM) configuration has been implemented and is now available for testing. We will discuss details of the implementation and present preliminary results comparing LAM and variable resolution approaches on two selected cases.

1-B-2.7
Latest Developments of Very High Resolution GEM-LAM Model over Mountainous Terrain
Uwe Gramann [1], A. Erfani [2], J. Mailhot [3], Sylvie Gravel [3], M. Roch [3] and L. Lefaivre [2]
[1] *Meteorological Service of Canada, Pacific and Yukon Region*
[2] *Meteorological Service of Canada, Canadian Meteorological Centre,*
[3] *Meteorological Service of Canada, Meteorological Research Branch*

The Pacific and Yukon Region (PYR) and the Canadian Meteorological Centre (CMC) are collaborating with the Meteorological Research Branch to evaluate the performance of a 2.5 km resolution limited area model centred over southern British-Columbia (BC). This project is testing the viability of the limited area model approach as a replacement for the existing global variable-resolution strategy used for the experimental HiMAP runs at CMC.

The GEM model is used in its limited area configuration and covers a very small domain over south-central BC including the west coast. The physical parameters are also adapted to this resolution, where the convection scheme is deactivated and a more complete cloud microphyics scheme is used. Runs in hydrostatic and non-hydrostatic mode have been conducted for several past high impact weather events. Considerations of induced topographical effects will be examined during the presentation along with current developments and future applications.

1-B-3.1-7
Cashing in on Corporate Canada?
CMOS private sector task force

There has always been a lot of discussion about the value of meteorological services to the economy. Everyone understands the need to know if they have to bundle the kids up for school or if there is a severe thunderstorm warning for their area. But what about meteorological services to private industry? Do we have the faintest idea what meteorological services the private sector wants? Do they? Do Canada's largest companies have any idea what meteorological services we can provide, and what impact these services might have on their bottom line? Are they prepared to pay for any of this? Join us at 10:20am on Wednesday June 4th when three senior executives from some of Canada's largest corporations answer these questions and more. Hosted by the CMOS private sector task force.

Session 1-B-4

Surface Ocean – Lower Atmosphere Study 1 / Surface de l'océan – Étude de la basse atmosphère 1

Chair / Président
Bill Miller

Monday 2 June 2003
lundi 2 juin 2003

Room / Salle Richelieu

1-B-4.1
The Role of Marine Storms in Air-Sea Gas Transfer
William Perrie, Weiqing Zhang, Xuejuan Ren and Zhenxia Long
Bedford Institute of Oceanography, Dartmouth, Nova Scotia

The long-term objective of this study is to determine a parameterization for air-sea gas transfer, related to dynamical variables such as waves, wind, currents, bubbles, wave-breaking, etc. suitable for implementation in a regional climate model coupled to an upper ocean model. This formulation should ultimately be of use to GCM simulations. However, in this study, our immediate objectives are much more *modest*. MC2 is coupled to POM (Princeton Ocean Model) and an operational wave model, WaveWatch3, from NCEP. The composite coupled model is employed to simulate high wind conditions and storms over the NW Atlantic. A formulation for bulk-to-bulk gas transfer, with generalized solubility and Schmidt number following Fairall et al. (2000, Bound. Layer Meteorology) is implemented. Gas transfer velocity estimates are based on two extressions: (1) wind-speed dependent formulations of Wanninkhof (1992) and Wanninkhof and McGillis (1999), and (2) the wave-breaking formulation of Toba and Zhao (2001, 6th International CO2 Conference). During storms, local gas concentration in the upper-ocean and lower atmosphere boundary-layer are strongly influenced by dynamical considerations related to sea surface temperature, upper-ocean currents, surface waves, and winds. Driven by surface winds, storm-induced surface currents can be quite large, of the similar magnitude as the Gulf Stream, if the storm has sufficient intensity. *On one hand*, marine storms occurring during the autumn may encounter a mixed layer that is thin. Thus, storm-induced currents may result in a cold wake, with SSTs depressed ~3-5^{o} C to the right of the storm track. *On the other hand*, if winter storms occur when the mixed layer is quite deep, the impacts on SSTs and the upper ocean temperature profile are relatively very minor although storm-induced surface currents are still quite strong.

We estimated the impact of high-wind conditions and mid-latitude storm events on air-sea CO_2 exchanges, using numerical sensitivity studies as well as real data event studies. For the latter, we assume climatological fields as background fields. Model results were verified with field data from **http://www.aoml.noaa.gov/ocd/oaces/**. Our results are consistent with those of Kawahata et al. (2001) and Bates et al. (1998), who did calculations based on field estimates to suggest conditions where both absorbance and efflux could occur. They suggest that the impact of a few storms on the air-sea CO_2 exchange is a considerable fraction of the annual exchange. Although our study is preliminary, our magnitudes are similar to theirs. Limitations in these calculations are that the parameterizations for gas transfer velocity may not be valid for high wind speeds, i. e. in excess of 30 m/s. This is a concern for either the Zhao-Toba wave-breaking formulation or the Wanninkhof wind algorithm. Moreover partial pressures for CO_2 may not behave linearly under these more severe conditions, as the storm-centre evolves.

1-B-4.2
Numerical Study on Uptake and Spreading of Chlorofluorocarbons in the Northwest Atlantic Ocean
Jun Zhao[1], Jinyu Sheng[1], Richard Greatbatch[1], Kumiko Azetsu-Scott[2], Carsten Eden[3]

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[2]*Bedford Institute of Oceanography, Halifax*
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Chlorofluorocarbons (CFCs) are anthropogenic compounds released to the atmosphere since 1930s. They enter the surface ocean by gas exchange and are then transported to the deep ocean by circulation, convection and subduction. CFCs are chemically inert in the seawaters. Their distributions in the ocean have been widely used to identify different water masses and pathways of thermohaline circulation. We use a three dimensional ocean circulation model known as FLAME to study the circulation, uptake and spreading of CFCs and water masses distribution in the North Atlantic during the 50-year period from 1950 to 2000. The model horizontal resolution is 4/3 degree with 45

unevenly-spaced z-levels in the vertical. We force the North Atlantic Ocean model with the monthly mean surface flux forcing of which interannual variability is associated with the NAO index. To improve the model performance in simulating circulation and active/passive tracers, we use the semi-prognostic method suggested by Sheng et al. (2001) and modified by Eden et al. (2002). This method is to adiabatically adjust an ocean circulation model by modifying the momentum balance. We compare the model calculated CFC12 with the observations in the northwest Atlantic region and estimate uptake and inventory of CFC12 in the Labrador Sea.

1-B-4.3

Evaluation of a New Model of DOM Dynamics in the Surface Ocean

Markus Pahlow[1], Alain F. Vézina[2]
[1]*Oceanography department, Dalhousie University*
[2]*Bedford Institute of Oceanography*

A model of plankton and DOM dynamics was developed with an adaptive formulation to accommodate responses of the plankton community to changing conditions. This approach makes simultaneously simple and general formulations possible. The model reproduces net DOM accumulation from plankton activity in the surface ocean and reconciles surface-marine DOC: DON ratios with the observed competition for inorganic nitrogen between bacteria and phytoplankton.

The model has been successfully tested on the Scotian Shelf. Comprehensive data sets collected from different sites in the North Atlantic allow a more rigorous evaluation of the generality of the model's formulation and parameterization. Preliminary results will be discussed.

1-B-4.4

The Photochemical Production of Dissolved Inorganic Carbon in the Delaware Estuary

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2. Department of Chemistry, State University of New York

In order to characterize the carbon cycle in the ocean, it is essential to quantify the *in situ* chemical transformations of dissolved organic matter (DOM). In summer 2002 we determined the spectral efficiency for the photo-oxidation of colored dissolved organic matter (CDOM) to inorganic carbon (DIC) at 6 stations within the Delaware estuary. DIC photoproduction was assessed along the salinity gradient in the estuary, from the freshwater end member (i. e., the Delaware river; Salinity ~ 0 psu) to a salinity of ~ 23 psu. DIC production rates, calculated from the quantum yield spectra, daily-integrated irradiance and CDOM absorbance, ranged from 1.38 umol C/L/hr for freshwater, to 0.17 umol C/L/hr for estuarine water. The calculated DIC production rates correspond with rates of DIC production determined from sunlight irradiations of samples on deck (1.43 - 0.22 umol C/L/hr). The observed rates verify that the photochemical production of DIC is important both as a sink for terrestrial DOM, and an *in situ* source of DIC in the Delaware estuary. For all estuarine stations (3 - 23 psu), the efficiency of DIC photoproduction was similar and did not vary with salinity or CDOM absorbance. Therefore at salinities > 3 psu, CDOM with a single spectral efficiency appears to control DIC photo-production throughout the Delaware estuary. In contrast, CDOM in the freshwater end-member produced DIC at a rate up to 4 times higher than that found elsewhere in the estuary. This increased rate of DIC production observed only in low salinity waters is consistent with the presence of one or more highly efficient organic compounds, occurring naturally or as a pollutant.

1-B-4.5

Development of a Three-Dimensional Physical-Biological Model for the N. Atlantic

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Session 1-B-4

Surface Ocean – Lower Atmosphere Study 1 / Surface de l'océan – Étude de la basse atmosphère 1

Chair / Président
Bill Miller

Monday 2 June 2003
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Session 1-B-4

Surface Ocean – Lower Atmosphere Study 1 / Surface de l'océan – Étude de la basse atmosphère 1

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Monday 2 June 2003
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[4]*St. Andrews Biological Station, St. Andrews, N. B.*

A simple ecosystem model is coupled to a 3-dimensional general circulation model for the North Atlantic. The model will provide context for the synthesis and modeling of the upcoming SOLAS field work in the N. W. Atlantic. The physical model is based on the Los Alamos Parallel Ocean Program (POP) and forced by climatological monthly mean data. Four biological components (phytoplankton, zooplankton, nutrients and detritus) are incorporated into the POP code as additional tracers with biological sources and sinks. The results are compared against monthly mean SeaWiFS colour data averaged over the period 1997-2002 and Levitus's climatological nitrate data. At present, only phytoplankton and nutrients are used as prognostic variables with zooplankton and detritus kept constant. The minimum complexity required for an adequate reproduction of the observed phytoplankton and nutrient fields will be discussed.

1-B-4.6

Seasonal Retrieval of Chlorophyll-A Concentration in the Northwest Atlantic Zone Using Remotely-Sensed Data: Application to the Spring Season.

Emmanuel Devred[1, 2], César Fuentes-Yaco[1, 2], Shubha Sathyendranath[1, 2], Carla Caverhill [2], Heidi Mass[2], Venetia Stuart[2] and Trevor Platt[2]
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[2] *Bedford Institute of Oceanography, Dartmouth*

Recent work has demonstrated the failure of the SeaWiFS OC4 algorithm in the Northwest Atlantic Zone and the need for a local algorithm to account for the regional characteristics. We present here a comparison of in situ measurements with satellite-derived chlorophyll-a concentrations. The satellite-derived chlorophyll concentrations were computed using the OC4 algorithm and a semi-analytical model (Sathyendranath et al., 2001) that accounts for seasonal variations in the spectral absorption properties of phytoplankton and detrital matter. The model was also extended to the near infrared region to account for the possible impact on the atmospheric correction procedure. The results for the spring season show a clear improvement in the retrieval of chlorophyll-a concentration when compared to results obtained using the NASA/OC4 algorithm.

1-B-4.7

Modelling the July 2002 SERIES Iron Fertilization Experiment

Kenneth L. Denman and Christoph Voelker
Canadian Centre for Climate Modelling and Analysis, University of Victoria

The eastern half of the subarctic North Pacific Ocean exhibits the characteristics of a high-nutrient low-chlorophyll (HNLC) region, where the macronutrient nitrate exists at high concentrations but the standing biomass of phytoplankton, measured as chlorophyll pigment is relatively low. The general consensus is that the standing stock of phytoplankton and /or the uptake of nitrate is regulated by some combination of low solar irradiance, episodic low silica concentrations, and most importantly low bioavailable iron. In July 2003, an experiment (SERIES) was performed near Ocean Station P where a patch of water ca 10 km square was fertilized with iron from a moving ship. The ecosystem response was tracked for several weeks by three different research ships. We have carried out simulations of the SERIES experiment with several different 1-dimensional coupled mixed layer ecosystem models. All simulations show a bloom response by the diatoms, but attributing the subsequent evolution of the patch between iron depletion and grazing has been difficult because the models seem to be highly sensitive to the parameters describing the relative strengths of the loss terms for the diatoms and the smaller sized nanophytoplankton. The different simulations result in varying levels of sequestration of nitrogen and carbon from the surface layer. Results will be compared with observations to be presented at the SERIES data workshop in March 2003.

Session 1-C-1

Climate and Climate Change 2 / Le climat et le changement du climat

Chair / Président
Allyn Clarke

Monday 2 June 2003
lundi 2 juin 2003

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1-C-1.1
Effects of Shallow Convection on Cloud Amounts and Radiative Fluxes in the CCCma GCM
Knut von Salzen and Norman McFarlane
Canadian Centre for Climate Modelling and Analysis, Meterological Service of Canada

A new parameterization of shallow convection has been implemented in a developmental version of AGCM4 of the Canadian Centre for Climate Modelling and Analysis (CCCma). The parameterization uses a bulk representation of an ensemble of transient clouds. Entrainment of environmental air occurs at the ascending top of the cumulus cloud and also at the lateral boundaries of the region below the top of the cloud. Complete detrainment of the air in the cloud occurs when the top of the cloud reaches its maximum height.

Tests with the CCCma AGCM have revealed considerable sensitivity of cloud amounts and radiative fluxes to the treatment of shallow convection in the model. It is demonstrated that, among other effects, vertical mixing processes associated with shallow convection substantially reduces simulated global amounts of low clouds. According to the GCM results, shallow convection does also affect the intensity of deep convection and chemical processes in the tropics.

1-C-1.2
Trade Cumulus Cloud Parameterization in Large Scale Models: Results from Large Eddy Simulations
Ming Zhao and Philip Austin
University of British Columbia Department of Earth and Ocean Sciences

Shallow cumulus clouds play a fundamental role in the redistribution of energy and moisture in the lower troposphere. While their influence is well established, there are currently a wide range of approaches for representing their ensemble effect in large-scale models. We use a 3-dimensional large eddy simulation of an equilibrium trade-cumulus boundary layer to evaluate assumptions that underly these cloud parameterizations. The LES is run at a uniform resolution of 25 meters on a domain of 256 x 256 x 128 grid cells; at this resolution it is possible to select and examine individual clouds over their entire life cycle. We use a passive tracer to isolate the "convective mixed region", i. e. that part of the near-cloud environment that is unsaturated but responsible for significant buoyancy and mass transport.

The simulations show that small clouds heat and moisten the boundary layer throughout their depth, while larger clouds heat/dry the cloud base region and cool/moisten the upper part the cloud layer. Thus the numerous small clouds observed in trade cumulus boundary layers play a central role in conditioning the cloud base environment and sustaining convection by larger clouds. This implies that the qualitative form of the size distribution is determined by the size-differentiated transport characteristics of these clouds in quasi-equilibrium with the large-scale forcing. We discuss the implications of this result for efforts to improve the representation of shallow clouds in climate models.

1-C-1.3
The Variability of Modelled Tropical Precipitation
J. Scinocca and N. McFarlane
Canadian Centre for Climate Modelling and Analysis

The temporal and spatial characteristics of deep tropical convection is currently a topic of great interest. Recently published studies have questioned the ability of current parameterizations of deep cumulus convection in GCMs to produce sufficient temporal variability. In particular, mass flux based (MFB) schemes, which typically produce very realistic seasonal mean distributions of tropical precipitation, are associated with the least amount of variability. This is an extremely important modelling issue since the variability of latent heating in the tropics affects the intraseasonal oscillation

and forcing of tropical waves which play a role in the quasi-biennial, and semi-annual, oscillations in the tropical stratosphere.

In this study, the properties of tropical precipitation in the Canadian Centre for Climate Modelling and Analysis (CCCma) third generation GCM (AGCM3) are investigated. AGCM3 employs the MFB scheme of Zhang and McFarlane (1995; ZM) for the parameterization of deep cumulus convection. Here it is found that the temporal variability of the precipitation produced by the ZM scheme depends strongly on several of its internal parameters and on the type of closure condition employed. The analysis indicates that the ZM scheme can match the level of "observed" variability (Horinouchi, 2002). An unexpected result of the present study is that the parameterized deep convection and resolved stratiform precipitation in the tropics experience a strong reciprocal interaction. That is, a change that increases the variability (and mean value) of one, decreases the variability (and mean value) of the other. This turns out to have a strong influence on the model biases of mean precipitation in the tropics.

1-C-1.4
Nonlinearity Of Extratropical Response To Tropical Forcing
Hai Lin, Jacques Derome
Department of Atmospheric and Oceanic Sciences and Centre for Climate and Global Change Research, McGill University

Observations and numerical modelling have shown that the global atmospheric response to tropical Pacific sea surface temperature forcing is nonlinear. Previous studies attribute this nonlinearity to the thermodynamics of tropical deep convections related to El Nino and La Nina.

In this study we use a primitive equations dry atmospheric model to investigate the atmospheric response to a diabatic forcing that is linearly associated with the first EOF of SST in the tropical Pacific, and explore if the atmospheric response is linear to this forcing. Analysis is made for 51 winter seasons (DJF) from 1948/49 to 1998/99. For each winter a time-averaged model forcing is first calculated empirically from the NCEP/NCAR reanalyses. Regression coefficients of this forcing field upon the Principal Components (PC) of the first EOF of SST in the tropical Pacific are calculated. By multiplying the regression coefficients with yearly values of the PC, we obtain time series of the forcing anomalies at each grid point that represents a linear fit of the forcing to this tropical El Nino type SST pattern. With this forcing anomaly for each winter, an ensemble of 30 integrations of 90 days is performed with different initial conditions. Composites of the ensemble mean 90 day averaged 500 mb geopotential height anomalies for El Nino and La Nina conditions show a nonlinearity feature that is similar to observations and previous model results. An EOF analysis of the ensemble mean of the 90-day averaged 500 mb height shows that the leading mode of the forced variability resembles the Pacific/North American pattern (PNA), while the second mode is a wave train across the North Atlantic to Eurasia. The relationship between the PC of the first mode and that of the tropical Pacific SST EOF is linear, while the PC of the second mode has a parabolic relationship with the El Nino related forcing.

A set of linear and finite amplitude nonlinear experiments with forcing perturbations and eddy flux anomalies associated with El Nino and La Nina conditions indicates that the nonlinearity of the extratropical response to tropical forcing is caused by transient eddies.

1-C-1.5

A Parameterization of Solar Energy Disposition in the Climate System

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During the past decade, a class of climate models of reduced complexity termed EMICs (Earth system Models of Intermediate Complexity) has been developed. Some of these models employ an energy and moisture balance model (EMBM) as the atmospheric component. However, the solar energy disposition (SED) in the subcomponents of these climate models using an EMBM has never been rigorously parameterized. In this paper, the SED into the atmosphere, at the surface and that escaped to space are first expressed as functions of the surface albedo and the integrated atmospheric reflectivity, transmissivity, absorptivity and cloud amount for a one-layer atmosphere which includes a cloud region and aerosols. Then an atmospheric radiative-convective model is used to parameterize the integrated atmospheric reflectivity and transmissivity in terms of cloud optical depth, aerosol optical depth and precipitable water. Next, the present-day climatology of the SED is calculated using the climatological data (for cloud amount and optical depth, aerosol optical depth, precipitable water and surface albedo) from ISCCP (International Satellite Cloud Climatology Project), ERA-15 (ECMWF 15-year Reanalysis) and PATMOS (Pathfinder Atmosphere). Since cloud amount data are used from three independent sources, three SEDs are in fact calculated and tested against the SED derived from satellite data. The calculated SEDs are much closer to the SED derived from satellite data than any one simulated in a number of AGCMs; thus the parameterized SED presented here is recommended for use in climate models which employ a one-layer atmospheric model.

1-C-1.6

On The Sensitivity of Modelled Precipitation to Closure Conditions for Cumulus Parameterisations

Lorant, Virginie and McFarlane, N., and Laprise R.
Canadian Centre for Climate Modelling and Analysis CCCMA, University of Victoria

Precipitation from stratiform clouds is fairly homogeneous in the horizontal and occurs over large areas. In contrast, precipitation due to moist convection is typically highly localized and non-homogeneous in the horizontal. However moist convection typically occupies a much larger vertical extent in association with the strong upward /downward air motion resulting from the overturning of the atmosphere which takes place during convective events. Therefore stratiform and convective precipitations induce markedly different vertical profiles of latent heat release and drying due to condensation. In order to simulate the effect of precipitation on the atmosphere it is therefore important to properly parameterize the distinct effects of stratiform and convective precipitation.

Summer simulations run with the Canadian Regional Climate model (CRCM) over the Baltic Sea region have shown that the split between stratiform and convective precipitation is significantly sensitive to the closure of the convection parameterization. The standard penetrative cumulus convection scheme used in the CRCM for this project is the mass flux type scheme with diagnostic closure as described by Zhang and McFarlane (1995). More recently a prognostic closure similar to that of Pan and Randall (1998) has also been implemented. A study of the sensitivity of the convection and stratiform precipitation statistics to this alternative closure condition has been carried out. Results from this study will be presented and the effects of varying key closure parameters will be discussed.

Session 1-C-1

Climate and Climate Change 2 / Le climat et le changement du climat

Chair / Président
Allyn Clarke

Monday 2 June 2003
lundi 2 juin 2003

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Climate and Climate Change 2 / Le climat et le changement du climat 2

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Monday 2 June 2003
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1-C-1.7
Transient Eddies Simulated in the CCCma GCMs: Eastward and Westward Moving Waves

Jian Sheng
Canadian Centre for Climate Modelling and Analysis

In this study, space-time series are expanded into wavenumber-frequency spectra. This technique allows the breakdown of transient eddies into eastward and westward moving components. The observational data used are from the daily ECMWF reanalysis for the 1986 - 1991 period. In the midlatitudes of both Northern and Southern Hemispheres, the power spectra are characterized by the eastward moving long waves. In the equatorial latitudes, tropical Madden-Julian waves are the dominant oscillation. The atmospheric and coupled general circulation models (GCMs) in CCCma simulate the midlatitude oscillations reasonably well. The energy level is lower than the observed in most of the wavenumber-frequency domain. The Madden-Julian waves are weak in both AGCM and CGCM. The wavenumber one structure shows two characteristic frequencies in the CGCM.

Session 1-C-2

Numerical Weather Prediction - COMM 2 / Prévision numérique du temps – COMM 2

Chair / Président
Louis Lefaivre

Monday 2 June 2003
lundi 2 juin 2003

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1-C-2.1
Spectral and Wavelet Analysis of Precipitation from Models and Radar
Charles A. Lin[1, 2, 3] Slavko Vasic[1], Isztar Zawadzki[2], Diane Chaumont[1] and Lei Wen[1]
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We perform a scale decomposition of precipitation fields from weather prediction models and compare with radar-retrieved precipitation fields. Two models are examined: GEM (Global Environmental Multiscale) model of the Meteorological Service of Canada, and the ETA model of NCEP (National Centers for Environmental Prediction) in the U. S. Precipitation values from the U. S. radar network are used to evaluate the model precipitation. A 6-day rain event from May 24-30, 2001 over a domain of extent 3,000 km in the continental US is examined. Spectral and wavelet methodologies are used for the scale decomposition of 3-hour precipitation accumulation in wavenumber space. The radar precipitation is aggregated to the model resolution, which is 24 km for both GEM and ETA models. The model results show less power than the radar at high wavenumbers. Cross spectral analyses of GEM/radar, ETA/radar and GEM/ETA are also performed, which reveal model bias and model uncertainty.

1-C-2.2
The Direct Assimilation of GOES (Infrared) and AMSU-B (Microwave) Radiances in 3D-Var At CMC
C. Chouinard, L. Garand, J. Halle, N. Wagneur
Meteoroological Service of Canada, Dorval

Data assimilation experiments were carried out to directly assimilate the GOES 6.7 micron IR radiance in replacement of the statistically-derived HUMSAT moisture profiles currently produced over the GOES East and West regions of NA. Parallel experiments were separately done to assimilate four AMSU-B radiances that are also sensitive to humidity. Over a 6-h time window, AMSU-B data from the three NOAA15-17 instruments produce a full global coverage from surface to above 250 hPa.

The positive impact from the individual data sources has been demonstrated separately, and the synergy between the two data types will be demonstrated over North and South America when both are assimilated together.

Significant changes to the global humidity analyses are observed in the lower and upper atmosphere with relatively smaller changes to the temperature. The impact on global precipitation forecasts is very significant and evaluated over North America against raingauge measurements. CMC is planning to implement the combined AMSU-B/GOES assimilation system in the spring of 2003.

1-C-2.3
Development of a Global Mesoscale Model for Medium-Range Weather Forecasting at the Canadian Meteorological Centre
Stéphane Bélair[1], Anne-Marie Leduc[2], Michel Roch[1], Paul Vaillancourt[1]
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A mesoscale version of the Global Environmental Multiscale (GEM) model, with uniform resolutions of 0.45 degree of longitude and 0.30 degree of latitude (i. e., a resolution of about 33 km at 49 degree of latitude), has been under development in the last two years at the Meteorological Research Branch and the Canadian Meteorological Centre. Apart from the increased horizontal and vertical resolutions (note that 58 levels are used in the new model instead of the 28 in the current operational configuration), significant changes are proposed to the representation of physical processes. The most important of these changes are the following: the Kain-Fritsch deep convective scheme replaces the

Kuo scheme; a so-called Kuo Transient scheme is now being used to represent shallow convective activity; and the mixing length used for the vertical diffusion processes (for boundary-layer turbulence) is now calculated using the Bougeault-Lacarrere technique.

Subjective evaluation of the results obtained up to now have revealed that this new high-resolution version of GEM improves the physical representation of large-scale as well as mesoscale weather systems, compared to the 0.9 degree model that is currently operational. Objective evaluation against radiosondes also indicate improvements during both the warm and cold seasons. Furthermore, the global-scale distributions of precipitation and clouds are believed to be improved. At the conference, we will briefly describe this new version of GEM that should be proposed for operational implementation at CMC in 2004, and provide an overview of the most significant improvements expected from this model.

1-C-2.4
Surface Modeling and Assimilation in the Canadian Global-Scale Model for Medium-Range Weather Forecast at the Canadian Meteorological Centre
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1 Canadian Meteorological Centre, Meteorological Service of Canada
2 Meteorological Research Branch, Meteorological Service of Canada

A new surface modeling and assimilation system is now being tested in the global medium-range weather forecast model used operationally at the Canadian meteorological centre. This surface system is similar to the system that has been implemented operationally in the short-range weather forecast model. It is based on the Interactions between Surface, Biosphere, and Atmosphere (ISBA) land surface scheme and on a sequential assimilation of soil moisture and surface temperature using model errors on screen-level air temperature and relative humidity. In the regional context, previous studies have shown that the main effect of the new surface system was to improve the representation of the surface diurnal cycle and of temperature and humidity in the lower troposphere. This new system was even shown to reduce precipitation biases. (These impacts were mainly found during the warm season, when heat and water exchanges between the surface and the atmosphere are the greatest.)

At the conference, we will show how the inclusion of this new surface system improves medium-range weather forecast. Results from global assimilation cycles will be presented, and the impacts on objective upper-air and surface verifications will be examined. Preliminary results have already shown positive impacts of the new system during the northern hemisphere winter. In the presentation, particular attention will be given to quantify the increase in predictability associated with better initial soil moisture.

1-C-2.5
Small-Scale Inner Core Structures and Wind Streaks in a Simulated Hurricane
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[2] National Center for Atmospheric Research
[3] Department of Meteorology, University of Maryland

This paper extends the results of a previous 72-h simulation of hurricane Andrew (1992) to include higher resolution and explicit simulation of convection in the inner-core region (radius < 200 km) with a cloud-resolving grid of 2 km using the PSU/NCAR non-hydrostatic model MM5. The model is integrated for 12 hours from 0000 UTC to 1200 UTC 24 August 1992, a period which covers the final fast-deepening stage and the landfall stage over Florida of Hurricane Andrew.

The results show that the thermodynamic and dynamic structures of the simulated storm in the 2 km run are similar to the coarser-mesh (6 km) run on the vortex scale. However, when compared to radar and other observations, it is found that there are significant improvements on the simulated structures of the inner-core eyewall, the spiral rainband and the organization of convection. Specifically, the

eyewall becomes much more compact and symmetric. The RMW is reduced by ~10 - 20 km and the width of the eyewall decreased by about half. The spiral rainbands are much better resolved. The model also captures the complex but realistic interaction between the vortex-scale dynamics and the convective motions, resulting in the generation of many interesting scale-interaction features in the regions of the eye and the eyewall. In particular, the strongest convection with a life cycle of < 30 minutes is located in the eyewall but with an intensity much stronger than the coarser resolution runs. A very strong potential vorticity (PV) zone is formed along the eye boundary in the deep troposphere. The ring of maximum PV is located in regions of maximum upward motion in the eyewall and it appears to take an active role in the organization of the eyewall convection. The outer spiral rainbands are characterized by negative and positive PV patches (< ± 5 PVU). The convective core in the eyewall region generates small-scale wind streaks. These streaks disturb significantly the vortex-scale surface maximum wind zone, similar to the observation reported by Wakimoto and Black (1994).

To shed light on the formation of the inner-core structures and the wind streaks, sensitivity experiments and an analysis of the azimuthal momentum budget were undertaken. The results will be presented.

1-C-2.6
Numerical Simulation of a Severe Hailstorm using a Double-moment Microphysics Scheme
Jason A. Milbrandt and M. K. Yau
McGill University, Montreal, Quebec

As the horizontal resolution of operational NWP models continues to increase, the models begin to fully resolve even relatively small-scale convective elements. The closure assumptions in convective parameterization schemes become less valid and it becomes appropriate to use condensation schemes that operate only when there is grid-scale saturation. Consequently, explicit microphysics schemes are playing an increasingly important role in quantitative precipitation forecasting (QPF).

Many microphysics scheme predict only the mass mixing ratio of the hydrometeor categories. Despite the added computational cost of predicting one more variable, predicting both the mass mixing ratios and the total number concentrations of each particle type - the double-moment approach - allows for a more realistic evolution of the particle size spectra and results in significant improvements to QPF. A fully double-moment bulk microphysics scheme has been developed and implemented into the Canadian MC2 mesoscale model. The scheme includes six distinct hydrometeor categories: cloud, rain, ice, snow, graupel and hail. Results of applying the scheme to the simulation of a severe hailstorm will be presented and the advantages of the double-moment method in improving QPF and in simulating large hail will be discussed.

1-C-2.7
Development of a New Bulk Mixed-Phase Microphysical Scheme
Wanda Szyrmer, Stephane Laroche and Isztar Zawadzki
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A growing number of recent studies emphasize the importance of representing cloud and precipitation microphysics in atmospheric models. The microphysical processes, on the one hand, influence the dynamics and on the other hand, they control the evolution of spectra of different types of hydrometeors. Due to a great complexity of microphysical processes, parameterization of these processes is obviously required. The choice of parameterization must be such that the interaction between thermodynamic and dynamic processes is accurately captured so that the dynamics is correctly influenced. This is the guiding principle in present microphysical parameterizations.

From the point of view of interpretation of measurements of remote sensing instruments, either ground-borne or space-borne, and their assimilation into numerical models another requirement must be kept in mind: it is important that the parameterization correctly represents the electromagnetic

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properties of the hydrometeors. This will determine the forward model and the degree of correct representativeness of the observation. Without this, data assimilation from remote sensing platforms will not be effective.

The double-moment microphysical scheme, in which both mixing ratio of mass and number concentration of each category are predicted, constitutes an improvement in relation to the one-moment scheme. However, it is still limited by an inherent assumption of a fixed curvature/width of the distributions. This is responsible, among others, for frequently large differences between the model results and radar observations. By adding an additional prognostic variable, the restriction of the constant width of the hydrometeor has been removed. Some examples of improvement using the new scheme will be presented.

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1-C-3.1
The Alliance Icing Research Study I (AIRS I)

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The Alliance Icing Research Study I (AIRS I) field project was conducted between 29 November 1999 and 19 February 2000. The main objectives of AIRS I were: 1) to improve our ability to remotely sense aircraft icing regions using satellite, aircraft or ground based systems, 2) to obtain additional data to characterize the icing environment which might be used in a revision of "Appendix C", the criteria used to certify aircraft for icing conditions, and 3) to improve our ability to forecast icing conditions and to understand how these conditions develop. An extensive array of remote sensing equipment was based at Mirabel airport to the north of Montreal, including: five microwave radiometers, an X-Band dual polarised scanning Doppler radar, an X-Band vertically pointing Doppler radar, a W-Band scanning Doppler radar, a Ka-Band scanning Doppler radar, and a multiple field of view scanning polarised LIDAR. In addition, scanning dual polarised S-band radar was operating at Ste. Anne de Bellevue, about 30 km SSE of Mirabel. The project aircraft were based out of Ottawa and flew most of their missions over the remote sensing equipment at Mirabel. The NRC Convair-580, the NASA Glenn Twin Otter, and a Learjet-25 operated by SPEC flew 25, 16 and 4 flights respectively. The Convair experienced 3 runback, 2-3 tail plane and 3-4 moderate-severe icing events. Icing was encountered on 4-5 flights with ambient temperatures colder than -20^{o}C. One Convair severe icing event over Mirabel, associated with small droplets, occurred at -29^{o}C. The Twin Otter saw moderate-severe icing on 2 days. An excellent data set was obtained, which provides good inter-comparisons between the aircraft in-situ measurements and the remote sensing data from Mirabel. For example, comparison between aircraft in-situ supercooled water contents and real-time algorithms based solely on the vertically pointing X-band radar are encouraging. Insights into the limitations and usefulness of remote sensors to detect icing environments will be discussed.

1-C-3.2
Aircraft Icing Environments in Canadian Winter Clouds

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In-situ measurements of aircraft icing environments have been made during 97 research flights conducted during four field projects. The field programs included the First and Third Canadian Freezing Drizzle Experiments, the First ISCCP Regional Experiment Arctic Cloud Experiment, and the Alliance Icing Research Study. A primary objective of three of these projects was the collection of in-situ microphysics data in order to characterize aircraft icing environments associated with supercooled large drops (SLD) >or= 50 µm in diameter. In all four programs, significant portions of each research flight were conducted in cloud environments that were conducive to aircraft icing. Icing environments were averaged over horizontal scales of approximately 3 km (30-second averages). For each 30-second measurement, the cloud temperature, altitude, liquid water content (LWC), ice water content, total water content, drop spectrum and ice crystal spectrum were measured with a large array of instruments. Drop spectra were measured between 1 and 3000 µm by combining measurements from several instruments. In total there were 13270 in-cloud measurements, of which 6628 were assessed to be icing environments with temperatures between 0 and -34^{o}C, liquid water content >or= 0.005 g m^{-3}, and ice crystal concentrations <or= 1 L^{-1}. The majority of the observations were made in stratiform winter clouds associated with warm frontal or low-pressure regions. For each 30-second measurement, a drop spectrum was determined, from which the mean volume diameter (MVD), maximum drop diameter (Dmax) and LWC could be computed. The 99.9 percentile LWC value was

0.7 g m-3, while the 99 percentile LWC for drops >or= 50 µm in diameter was 0.2 g m^{-3}. The 99.5 percentile values of LWC and droplet concentrations are determined for different horizontal length scales and droplet diameter intervals, and are used to characterize the extreme icing conditions observed. The largest MVD observed were approximately 1000 µm and represent cases where the aircraft was flown below cloud base in freezing rain conditions. Approximately 39% of the drop spectra observed contained SLD >or= 50 µm in diameter, and 8% had MVD > 40 µm. A technique for averaging multiple spectra together was developed in order to determine average drop spectra. The analysis is presented in a format that is suitable for several applications within the aviation community, and comparisons are made to several common icing envelope and spectra characterization formulations. The results should be beneficial to regulatory authorities, which are currently attempting to assess certification requirements for aircraft that are expected to encounter freezing precipitation conditions.

1-C-3.3
Matching Ground-Based Radar Data to In-Situ Aircraft Measurements
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The Alliance Icing Research Study I (AIRS I) field project was conducted during the winter of 1999-2000 in the vicinity of Mirabel airport near Montreal. Its primary objectives were to improve our ability to remotely sense aircraft icing regions and to study the cloud microphysical conditions within them. The concerted plan was to collect a coordinated dataset that combined in-situ aircraft and ground-based radar data.

The NRC Convair-580 and NASA Twin-Otter aircrafts collected in-situ data performing predetermined sets of manoeuvres (constant altitude reciprocal runs, missed approaches and spiral ascents/descents). Ground-based radar data were collected by the McMaster University portable X-band (IPIX) radar deployed at Mirabel, and the McGill S-band radar at the Marshall Radar Observatory (MRO) about 30 km SSE of Mirabel. The IPIX radar employed a scan strategy, comprised of sector scans and antenna stares at preset elevations along the runways axis, intended to follow the aircraft. The MRO radar employed a fast scanning strategy performing 24-elevation full volume scans every 5 minutes.

Aircraft microphysical data were averaged to 30 s resolution or approximately 3 km horizontally. The data matching methodology involved extraction of a 2D subset of the ground radar data centred on the aircraft GPS position. Thus for each in-situ point, spatial averaging and de-spiking of the aircraft echo itself could be performed.

For both MRO and IPIX radars, statistics of the remote and in-situ data matching stratified by aircraft manoeuvre will be presented. MRO's fast scanning cycle proved to generate a good level of quantitative matching, whereas IPIX demonstrated better qualitative matching but fewer "hits". In future campaigns, better air-to-ground coordination via real-time aircraft position feedback should improve the matching quality of a strategically scanning ground-based radar. Finally, a comparison of the ground radar measured and aircraft derived reflectivities will highlight the inherently different sampling volumes and sensitivities that must be taken into account in the interpretation of the combined dataset.

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1-C-3.4
Discrete Modelling Of Ice Accretion under In-Flight Icing Conditions
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A two-dimensional, discrete element, morphogenetic model has been devised to predict both the accretion shape and the structural and physical details of the ice accretions forming on a cylinder and an airfoil over a wide range of atmospheric and flight conditions. To the best of our knowledge, our model allows for the first time, the prediction of both the ice shape and density of aircraft ice accretions. We have produced morphogenetic model simulations of ice accretions under rime, glaze and mixed glaze/rime conditions, as a function of the controlling parameters: air temperature, liquid water content, airspeed, and supercooled cloud droplet diameter. We have partially verified the model using experimental data. The results are encouraging, showing that the morphogenetic model simulates ice accretions on a cylinder and an airfoil, in reasonable agreement with experimental data. In addition, a comparison with existing numerical models suggests that our model seems to be as accurate as the best existing icing models, while offering greater flexibility and computational efficiency. A significant novel feature of the model is that it allows the direct simulation of the stochastic variability of the accretion shape and structure under constant external conditions. There is also the potential that morphogenetic modelling may allow prediction of 3D ice structures called "lobster tails." No existing model is capable of predicting these highly convoluted ice structures.

1-C-3.5
Preliminary Results from the Alliance Icing Research Study 1.5 (AIRS 1.5)
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The Alliance Icing Research Study 1.5 (AIRS 1.5) field project was conducted between December 2002 and February 2003. The main objectives of AIRS 1.5 were to undertake a proof of concept project in preparation for AIRS II and to collect data for the development of the Airport Vicinity and Snow Advisor (AVISA). A ground site at Mirabel, Quebec, was instrumented with: two microwave radiometers from the University of Manitoba and the Mont Washington Observatory, the McGill Vertically Pointing Radar, a Precipitation Occurrence Sensor System, hot plate precipitation gauges, a 10 m tower with associated sensors, visibility, ceiling and fog sensors, and a Barnes PRT-5 for cloud base black body temperature. The NRC Convair-580 was flown over the site to collect cloud microphysics in-situ, and remote sensing data to validate algorithms under development for AVISA. Two moderate-severe icing episodes were documented using the Convair over Mirabel on 19 and 22 February 2003. In addition, two flights were made into a major snowstorm of 22-23 February 2003. This paper gives an overview of the experiment, and the data collected. Some insights on how the data will be used for AIRS II and AVISA will be presented.

1-C-3.6
Validation of A GOES Satellite Icing Algorithm with In-Situ and Ground Based Observations during AIRS 1.5
I. Gultepe, G. A. Isaac, N. Driedger, J. Reid, D. Hudak, W. Strapp, and S. G. Cober
Cloud Physics Research Division, Meteorological Service of Canada

In this work, the icing regions defined by an analysis of the GOES satellite measurements are validated using in-situ data, Doppler radar, and ground base measurements that included air temperature (T), cloud base temperature (Tb), and liquid water path measurements. Observations collected during the Alliance Icing Research Study (AIRS 1.5) field project, which took place over the

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Ontario and Quebec region during the Winter of 2002/2003, are used in the analysis. The six flights, where icing conditions were encountered, are being analyzed. During the field project, some icing cases were observed that are missed by the algorithm developed based on GOES observations. The relationships between microwave radiometer (MWR) derived liquid water path (LWP) and cloud top temperature (also Tb) will be used to determine icing regions. These will be compared with those indicated by the satellite algorithm. Preliminary results indicated that the GOES algorithms were not able to successfully identify all cloud top icing regions and reasons for these discrepancies will be discussed.

1-C-3.7
Aurora as an Interface to the Airport Vicinity Icing and Snow Advisor (AVISA)
Brian Greaves, Norbert Driedger, Bob Paterson, and Janti Reid
Cloud Physics Research Division, Meteorological Service of Canada

Aurora is a software platform developed within the Meteorological Service of Canada for abstract representation of meteorological fields. The primary intent of Aurora is to provide a case study tool for research into different aspects of severe weather research. Aurora can represent various types of forecast and observational data at multiple scales in space and time. Aurora can also be used to identify, synthesize, and annotate features within the context of a graphical database.

A current application of Aurora is as an interface to provide meteorological information to the Airport Vicinity Icing and Snow Advisor (AVISA). AVISA is a rule-based system for integrated diagnosis of severe weather hazards from multiple sensors and forecast information. Development of AVISA will investigate the types of information necessary to determine severe weather hazards, and the impact of various information types on the system. Aurora can feed information extracted from available datasets using a variety of equations, techniques or processes to the AVISA system.

By connecting the rule-based inference capabilities of AVISA to the representational capabilities of Aurora, a better understanding of interrelated phenomena will be possible. Some of the capabilities of Aurora will be presented using AIRS-1.5 case studies and their application to AVISA.

1-C-3.8
Construction of the Airport Vicinity Icing and Snow Advisor (AVISA)
Norbert Driedger [1], George Isaac[1], Janti Reid[1], Stewart Cober[1], Walter Strapp[1], Ismail Gultepe[1], David Hudak[1], Norman Donaldson[1], Anna Glazer[2], Frédéric Fabry[3]
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Previous AIRS (Alliance Icing Research Study) field projects have yielded interesting characterizations of icing environments. The next step is to directly or indirectly detect icing conditions remotely and encode knowledge about such environments in software. All remote sensing instruments have limitations with regards to detecting supercooled liquid water (SLW) or supercooled large drops (SLD). By combining the readings of multiple sensors, an improved diagnosis of inflight icing potential and ground based weather hazards can be achieved. The Airport Vicinity Icing and Snow Advisor (AVISA) is an evolving prototype of an intelligent integrated observing system. AVISA is a rule-based system with potential for fuzzy logic inference. AVISA combines forecast information with observations from GOES satellite, scanning radar, ground-based radiometers, the McGill vertically pointing radar (VPR), a hot plate snow gauge, a Precipitation Occurrence Sensor System (POSS), and standard met station instruments. Data collected during the AIRS-1.5 field campaign is being used for ongoing algorithm development in preparation for AIRS-2. Examples from AIRS-1.5 with preliminary results will be presented.

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1-C-4.1
An Unusual Climate Event in the Gulf of Alaska: The View from Argo.
Howard Freeland
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During the summer of 2002 the surface waters of the Gulf of Alaska warmed dramatically, and at the same time there was a massive intrusion of cold and fresh water between 75m and 120m depth. When this occurred a large part of the Argo array was already in place and this has allowed a remarkable view of the step-by-step evolution of a very unusual climate fluctuation. This talk will present a description of the climate events seen and focus on the detailed view allowed by Argo.

The climate event caused a dramatic change to the stratification of the upper water column and this coincided with a winter in which the Gulf of Alaska experienced very few storm-like events. The result is that the normal mid-winter mixed layer depths of 120 metres were not achieved during the winter of 2002/03 over a large part of the Gulf of Alaska. However, the near-surface stratification was anomalously large by the mid-summer of 2002, and this had a significant impact on the behaviour of the water-mass fertilised in the SOLAS/SERIES experiment.

1-C-4.2
Silicon Cycling in the Gulf of Alaska
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The prevailing view of world HNLC waters is that phytoplankton growth is limited by iron supply. In the Gulf of Alaska, deck incubations have repeatedly confirmed that with iron addition, diatoms bloom and nitrate is completely utilized. However, incidents of Si depletion in the subarctic Pacific have been observed under both well-defined and poorly understood conditions.

The recent SERIES (Subarctic Ecosystem Response to Iron Enrichment Study) experiment has helped define an important process in HNLC waters which has only recently been described in other HNLC regions. When iron enrichment occurs in open waters, either from controlled inputs by humans or from natural process such as mesoscale eddies or atmospheric deposition, we observe Si depletion with surplus nitrate. This occurs because the biological community in open ocean efficiently retains N and other organic materials in surface waters, whereas Si turnover occurs at a much slower rate. We estimate that Si is exported from the upper ocean 6 times more efficiently than N and several times more efficiently than C. Such fractionation of biogenic materials has been termed the Si Pump. The implications of iron enrichment on transfer of carbon into the interior ocean must therefore be tightly coupled with Si cycling rather than N.

In summer 2002, a survey of surface waters in the Gulf of Alaska defined 3 water types. Coastal waters are seen to be Si and Fe rich (nitrate limitation), HNLC waters display Fe limitation with a tendency towards Si depletion, and a transitional domain experiences macronutrient limitation (generally nitrate but also Si). Using data collected over the past several years, we estimate the supply ratios of Fe: Si: NO_3 from intermediate waters to the upper ocean in these 3 realms. The differences in supply ratios provide an estimate of the threshold at which oceanic ecosystems will switch from Fe to Si or NO_3 limitation.

1-C-4.3
The Response of Phytoplankton to the Addition of Iron into the Otherwise Iron-Limited Waters of the Subarctic NE Pacific Ocean
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The subarctic NE Pacific is one of the three large high nitrate, low chlorophyll (HNLC) regions of the world oceans. The region shows limited seasonal change in chlorophyll, and, it has been demonstrated that phytoplankton primary productivity in the sub arctic NE Pacific is limited by the availability of iron. As such, iron mediated primary production is likely to have a considerable regional impact, not only on food web structure and energy flow, but also on the production and sequestration of climatically active gasses (e. g., CO2 and dimethylsulfide (DMS)). Understanding the biological and geochemical response of the subarctic NE Pacific to an iron addition event is central to our ability to predict how the oceans will respond to and influence climate change in the future.

On 9 July 2002, the Canadian SOLAS program added dissolved iron to a 64 km2 patch of the subarctic NE Pacific, and followed the evolution of the subsequent phytoplankton bloom for 26 days. Primary productivity inside the patch began to increase relative to outside the patch within the first 48 h. Primary productivity peaked on 24 July (~3 g C m-2 d-1, day 14) associated with a sharp decrease in silicic acid toward limiting levels. Chlorophyll concentrations were maximal (~10× background) from 25 - 27 July after which the bloom began to decline. Until after the second addition of iron to the patch on 16 July, productivity for both smaller and larger sized phytoplankton increased. However, as the bloom progressed, the largest phytoplankton size fraction, made up primarily of diatoms, accounted for the vast majority of both primary productivity and chlorophyll. As primary productivity increased over the course of the bloom, and as diatoms became increasingly dominant over flagellates, the proportion of primary production released as dissolved organic carbon decreased substantially.

1-C-4.4

Microbial Response to a Mesoscale Fe Enrichment in the Northeast Subarctic Pacific: Growth

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The Subarctic Ecosystem Response to Iron Enrichment Study (SERIES) was a mesoscale Fe enrichment study conducted during July 2002 in Northeast subarctic Pacific. Here we report on the response of the mixed layer microheterotrophic community to multiple additions of Fe. The initial addition of Fe to a 64 km^2 area on July 9th increased the ambient Fe concentration to ~4 nmol. Mixing reduced the Fe concentration to approximately 1 nmol by July 13th. A second addition of Fe on July 16th increased the ambient Fe concentration to ~2 nmol. During this period, mixed layer depth varied about 2-fold (20 - 47 m) with it typically being 30 m. Only small change in bacterial abundance, production and growth rate were observed outside of the Fe patch. Inside the patch, bacterial abundance decreased 4-fold for the first 11 days of the experiment , corresponding to a grazing mortality of approximately -0.13 d^{-1}. This rate is similar to the annual average rate of grazing mortality of bacteria measured using dilution assays and previously reported for bacteria at Station P (i. e. 0.2 - 0.3 d^{-1}). About two weeks after the initial Fe addition, the abundance of bacteria rapidly increased, corresponding to an apparent growth rate of ca. 0.53 d^{-1}. This growth rate is comparable to the summertime bacterial growth rate of 0.56 d^{-1} reported previously at Station P. Bacterial production increased 7-fold over the observation period, to a maximum value of 7.85 mg C m^{-3} d^{-1} (July 28th), and bacterial growth rate increased 9-fold to a maximum value of 1.07 d^{-1} (July 22nd). The increases in bacterial production and growth rates reported here are significantly larger than those reported from mesoscale Fe fertilization experiments in the equatorial Pacific Ocean and the Southern Ocean, where bacterial production increased 3-fold and growth rates increased 3- to 4-fold. Community respiration rates within the mixed layer inside the Fe patch ranged from 19 to 61 mg C m^{-3} d^{-1}. These values were consistently higher than those measured within the mixed layer outside the patch, which ranged from 6 to 12 mg C m^{-3} d^{-1}. We propose that the addition of Fe into the patch changed the dynamics and structure of the microbial food web and this has important implications for the cycling and export of carbon in the upper ocean.

1-C-4.5

Stable Nitrogen Isotope Dynamics of a Phytoplankton Bloom: Results From the SERIES Experiment In The North Pacific Ocean.

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The natural abundance ratio of the stable isotopes of nitrogen can potentially provide valuable information about the nitrogen cycle of the oceans on a wide range of spatial and temporal scales. Knowledge of the isotope fractionation effects on the 15N/14N ratio during nitrogen transformations, combined with the ability to measure the ratio in important nitrogen pools, can provide quantitative information on the biogeochemical processes that contribute to the flux of nitrogen in the water column and to marine sediments. The use of 15N/14N ratio of sediments to reconstruct the nitrogen dynamics of the ocean over geological time scales is an active area of research, and it is now recognized that nitrogen isotope measurements in sedimentary sections offer an important proxy for studies of global climate change. As part of the Canadian SOLAS program, the isotopic dynamics of nitrogen were monitored during the SERIES iron addition experiment in the HNLC region of the North Pacific Ocean. The phytoplankton bloom that resulted from the addition of iron was monitored for a two-week period, and measurements for the isotopic analysis of nitrogen were collected daily. A strong isotopic signal generated from nitrate uptake by phytoplankton was found, and the subsequent change in the 15N/14N ratio of nitrate, size-fractionated phytoplankton, and sinking particles was observed as the nitrate in the surface waters was depleted. Evidence of the phytoplankton bloom was detected from the 15N/14N signal in sediment traps at 50, 75, 100, and 125 metres depth, and suggests that the nitrogen isotope signal of the phytoplankton bloom was exported out of the euphotic zone. The findings of this study help elucidate the complex nitrogen dynamics of the iron fertilization event and enhance our understanding of small-scale changes in nitrogen isotope ratios in the surface ocean. We will present a summary of the results from this experiment that provide further evidence that nitrogen isotopes can be used to analyze complex transformations of nitrogen in the ocean.

1-C-4.6

SERIES (Sub-arctic Ecosystem Response to Iron Enrichment Study) in HNLC Waters in Northeast Pacific Ocean

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In July 2003, the Climate Chemistry Laboratory at the Institute of Ocean Sciences, conducted an iron enrichment experiment: SERIES (Sub-arctic Ecosystem Response to Iron Enrichment Study) as the first major field work of Canadian SOLAS at Station P (50ºN, 145ºW) in the Northeast Pacific Ocean The water mass is within the HNLC (high nutrient low chlorophyll-α) regime poor in iron required for diatom growth. Iron fertilizer was added and the iron patch was tracked by both sulfur hexafluoride (SF_6) and drifting drogues. The presentation described the three-weeks observations conducted by the Climate Chemistry Laboratory: iron concentrations and chemical speciation, SF_6 mapping, ${}_pCO_2$, carbon budgeting including results of carbon, nitrogen and opal fluxes from drifting traps; dimethyl sulfide (DMS), a "cooling" climate gas, inside and outside the patch. SERIES is the first iron experiment conducted in the Northeast Pacific, a HNLC regime with unique biogeochemical features, such as significantly large detritus flux from high primary production not reflected in the usually low chlorophyll concentrations. A satellite image of the elevated level of chlorophyll during the experiment demonstrated the biogeochemical consequence of iron fertilization, which increased the phytoplankton biomass and CO_2 uptake from the atmosphere, hypothesized by Martin to be the controlling factor in glacial-interglacial shift. The study provides vital information to assess the practicality of enhancement of natural CO_2 sink as an approach to mitigate the atmospheric carbon burden, a major societal problem in this century.

Session 1-C-4

Surface Ocean – Lower Atmosphere Study 2 / Surface de l'océan – Étude de la basse atmosphère 2

Chair / Président
Frank Whitney

Monday 2 June 2003
lundi 2 juin 2003

Room / Salle Richelieu

1-C-4.7

The Response Of DMS(P) Production Rates To Fe Enrichment In The NE Pacific: A Shipboard Microcosm Experiment

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Production rates of DMS and DMSP were determined in shipboard micocosm incubations during the SERIES Fe-enrichment experiment at Station Papa in the Fe-limited zone of the NE Pacific. 8 microcosms (20 L) were maintained in a deck incubator under natural light. Four (duplicated) treatments were employed: 1) Control (unenriched seawater), 2) Fe-enriched (4 µM), 3) Fe- and Ge-enriched (4µM and 80µM), 4) Seawater from the enriched patch (approx 4 µM Fe). The Ge-enriched treatment was employed as a diatom growth inhibitor in an attempt to elucidate the relative role of diatoms and other species in DMS(P) production during iron enrichment. DMS and DMSP concentrations were determined every 2 d along with Chl *a*, nutrients, phytoplankton abundance, bacterial abundance and bacterial production. All treatments showed similar increases in Chl a (0.5 - 1 µg L^{-1} d^{-1}), peaking after 8 d and then declining rapidly into senescence. Although no significant differences in total Chl *a* production were observed between the treatments, the Ge-enriched samples showed a relatively greater amount of
Chl *a* in the smaller size fractions than in the larger ones, commensurate with an inhibition of diatom growth. DMS production was elevated in the Fe-enriched treatments compared to the controls. This mirrored very well the changes observed in the water column. DMS net production rates reached 2 nmol L^{-1} d^{-1} in the Fe-enriched incubations (1 nmol L^{-1} d^{-1} in the water column) while unenriched controls showed little or no change. Particulate and dissolved DMSP production showed almost no differences between treatments, with a general increase until Day 8 followed by a decline. The exception was the Ge-enriched treatment, where particulate DMSP production was ca. 2-fold higher than the other treatments. DMS and dissolved DMSP production in the Ge-enriched treatment was initially similar to the controls, but then increased rapidly toward the end of the experiment. Bacterial abundance and production increased over the course of the experiment in all treatments except Ge-enrichment which remained low and fairly stable, in spite of the large growth Chl *a*. The similarity in bacterial abundance and production between treatments suggests that the stimulation of DMS production by Fe-enrichment is related to the phytoplankton species assemblage.

1-D-1.1
The Nonlinear ENSO Mode And Its Interdecadal Changes
Aiming Wu and William W. Hsieh.
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Nonlinear canonical correlation analysis (NLCCA) via a neural network approach was applied to the monthly surface wind stress (WS) and sea surface temperature (SST) in the tropical Pacific for the period 1961-1999. To examine interdecadal changes in ENSO, the NLCCA was applied to the subset data for the 1961-75 and 1981-99 periods, separately. The leading NLCCA mode between the WS and SST reveals notable interdecadal changes of ENSO behaviour before and after the mid 1970s climate regime shift, with greater nonlinearity found during 1981-99 than during 1961-75. Spatial asymmetry (for both SST and WS anomalies) between El Niño and La Niña episodes was significantly enhanced in the later period. During 1981-99, the location of the equatorial easterly anomalies was unchanged from the earlier period, but in the opposite ENSO phase, the westerly anomalies were shifted eastward by up to 25 degrees. According to the delayed oscillator theory, such an eastward shift would lengthen the duration of the warm episodes by up to 45%, but leave the duration of the cool episodes unchanged. Supporting evidence was found from observations, and from a hybrid coupled model built with the Lamont dynamical ocean model coupled to an empirical atmospheric model consisting of either the leading NLCCA or CCA mode.

1-D-1.2
Parameterization of Subsurface Temperatures in the Lamont Ocean Model using Neural Networks
Shuyong Li, William W. Hsieh and Aiming Wu
Dept. of Earth & Ocean Sciences, University of British Columbia, Vancouver

In the Lamont coupled model of the tropical Pacific, the ocean model uses a simple parameterization scheme for the subsurface temperature, which is replaced here by a neural network (NN) scheme. The input neurons of the feed-forward NNs are the eight leading principal components (PCs) (i. e. EOF time series) for the 20 °C isotherm depth, and the output neuron is one of the six leading PCs of the subsurface temperature. Forced by the Florida State University wind stress, the ocean models were run from January 1964 to August 2001. The numerical results show that the new ocean models simulate the sea surface temperature anomalies (SSTA) better than the original Lamont ocean model. Principal component analysis (PCA) and nonlinear principal component analysis (NLPCA) of the SSTA also show the new ocean model to be more realistic than the original Lamont ocean model.

1-D-1.3
Stochastic Modeling of Precipitation for Canada
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Stochastic weather models are frequently used to supplement observed daily climatological data and to provide a way to simulate the long-term effects of weather variability. This study is to exhaustively test the performance of precipitation models in reproducing daily precipitation statistics across Canada. Possible solution to improve interannual variability by perturbing monthly parameters is discussed. The effects of estimating model parameters using different methods for Gamma distribution are investigated with their capacity to represent observed extreme daily precipitation amounts. Daily precipitation data from 657 stations, representing a wide range of precipitation climates, are considered. The simple first-order Markov model for daily precipitation occurrence is found to be generally adequate for the Canada stations studied. Mixed Exponential distribution model for daily precipitation amounts is clearly superior to commonly used Gamma distribution model in summer season from April to October, in winter Gamma distribution is chosen most often, particularly for locations in the west-south area. L-moment method for estimating parameters for Gamma distribution can effectively reduce the negative bias of daily extreme precipitation commonly

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Climate and Climate Change 3 / Le climat et le changement du climat 3

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found in weather generators that uses the method of maximum likelihood to estimate the parameters of Gamma distribution. Suggestions for model applications are given.

1-D-1.4
Wind Energy Mapping As A Regional Climate Modeling Problem
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Environment Canada has developed a new high-resolution wind energy potential mapping tool, WEST (Wind Energy Simulation Toolkit), that has begun to be applied to different regions for the need of the wind energy industry of Canada. The heart of the system is a limited-area mesoscale model. The emphasis is put on the statistical treatment of the large-scale climate data and efficient modeling techniques. The wind mapping strategy and some validation results will be presented.

1-D-1.5
Developing Daily Climate Scenarios For Agricultural Impact Studies
Budong Qian, Sam Gameda, Henry Hayhoe, Reinder De Jong and Andy Bootsma
Eastern Cereal and Oilseed Research Centre, Agriculture and Agri-Food Canada, Ottawa

Assessment of climate change impacts on Canadian agriculture is fundamental for policy makers to develop adaptation strategies to climate change. Most climate change impact models (e. g. crop growth and soil erosion models) require daily climate data on a fine spatial resolution (e. g. on a 0.5°x0.5° grid) in order to be compatible with other model inputs like soil's data and soil and crop management practices. Daily climate scenarios are available from state-of-the-art climate models (GCMs or General Circulation Models) on a much coarser resolution (typically on a 3.75°x3.75° grid); moreover, their surface climate variables are not as reliable as large-scale atmospheric circulation data. Therefore, daily climate scenarios from climate models are, essentially, not appropriate as direct inputs in impact models. Downscaling techniques, either dynamical or statistical, have been widely used to bridge the gap between climate and impact models. Because of its simplicity and computational inexpensiveness, a statistical downscaling technique was adopted in this study to develop daily climate scenarios (daily maximum and minimum temperatures, precipitation and solar radiation, the most important climate parameters for agricultural application) on a 0.5°x0.5° grid covering the Canadian agricultural region, for the 2040-2069 period.

Statistical downscaling techniques can be classified into two categories: stochastic and deterministic. Deterministic techniques, such as transfer functions (either linear or nonlinear regressive models), usually are not able to capture the high daily variability of the weather conditions. In contrast, stochastic methods, such as weather generators, can simulate most statistics of daily weather variables very well. Weather generators also have the advantage of producing as many realizations as needed for input into impact models to capture a range of climatic variability scenarios. In order to apply the weather generators for future climate scenarios, conditional weather generators on large-scale atmospheric circulation (e. g. daily circulation patterns or weather types) are the straightforward techniques, while adjustments are required to the parameters in unconditional weather generators for a future changed climate. Because the climate in the Canadian agricultural region is highly diverse, the unconditional weather generator approach, which employs empirical distributions to account for this diversity, was used.

This paper presents a daily climate scenario development methodology that uses weather generators for Canadian agricultural impact studies and explores strengths and limitations of this approach. Adjustments to the weather generator parameters are based on changes in means and standard deviations of weather variables from the baseline period 1961-1990 to 2040-2069, simulated by HadCM3 and CGCM1 climate models with emission scenarios SRES-B2 and IS92a respectively, in order to reflect the uncertainties in climate scenario construction.

1-D-1.6

Statistical Downscaling Models Robustness: A Regional Case Study Approach for Quebec

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Evaluation, utilization and validation of the statistical downscaling tools are very important steps for the construction of climate scenarios for : 1) stakeholders implicated in the evaluation of the impacts of climate variability and of climate change and 2) decision makers that regard information related to climate change as being an integral variable in planning resources, activities and programs for a new climate reality. Statistical Downscaling (SDS) models used for this purpose shall be rigorously and systematically inter-compared over a wide range of climatic conditions. The most commonly SDS models used in Canada (Statistical Downscaling Model -SDSM , and Long Ashton Research Station Weather Generator- LARS-WG) are evaluated for the analysis of historical extreme events and climate variability. Daily precipitation and maximum, minimum, and mean surface temperature series are simulated for different regions in Quebec. The ability of the statistical downscaling models to simulate these variables are evaluated using (1) time series plots, model bias and explained variance statistic, (2) extreme indices produced by STARDEX Diagnostic Extremes Indices Software (SDEIS-A : adjusted version 3.2.4). SDEIS-A is applied to calculate indices using statistically downscaled GCMs and observed daily time series. A comparison between indices derived from statistically downscaled GCM output and observed data enables estimation of uncertainties introduced by using GCM output and statistical downscaling.
STARDEX software is available at: http://www.cru.uea.ac.uk/cru/projects/stardex/

1-D-1.7

Building Climate Change Scenarios Of Temperature And Precipitation - A Pilot Project For Canada Using The Statistical Downscaling Model (SDSM)

Gary S Lines
Meteorological Service of Canada

The Intergovernmental Panel on Climate Change (IPCC) has established that General Circulation Models (GCM's) are the only credible tools for projecting climate change into the future (2100). However the horizontal resolution of most existing models is too course (300 x 400km) to be used in most impact studies. Two methods currently exist that could provide information on a finer scale. Projected output can be obtained dynamically by using a Regional Climate Model (RCM), or statistically by 'downscaling' global scale climate variables projected by General Circulation Models (GCM's). Since no RCM model is currently available for Atlantic Canada, statistical techniques were used to generate the downscaled climate variables of interest. The model selected was the Statistical Downscaling Model (SDSM) developed by Rob Wilby et al. (2001), at King's College, London.

High quality daily maximum temperature, daily minimum temperature, and total daily precipitation data were obtained from 15 sites across Canada for the 30 year base climate period 1961-90. Temperature data was obtained from the Historical Canadian Climate Database (HCCD) web site, where the data had been 'homogenized' to correct for any observational inconsistencies. The latest version of homogenized precipitation data was unavailable, therefore quality controlled archived data was used.

SDSM is a hybrid of regression and stochastic downscaling methods. To develop the initial statistical relationships, daily observed values of temperature or precipitation from the first half of the base climate period were regressed against National Centre for Environmental Prediction (NCEP) reanalysis predictor variables for the same period. The regression parameters were then validated using data from the second half of the base climate period. Projected outputs were then obtained using future climate variables (predictors) extracted from various GCM experiments. This study used the

Canadian coupled global climate model (CGCM1) developed at the University of Victoria BC and the Hadley Centre model (HadGCM) from the UK.

With the resulting downscaled values of projected temperature and precipitation one can build climate change scenarios for that site. To make the results much more available to climate change impacts researchers who may require climate variables on a site-specific scale, a GIS mapping interface was developed to provide access geographically, on a regional or community basis.

1-D-1.8

A Synoptic Climatological Approach to Assess Possible Impacts of Climate Change on Freezing Rain in South Central Canada

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Meteorological Service of Canada - Ontario Region, Environment Canada

Freezing rain is a major weather hazard which affects many parts of Canada; however, it is especially common in a corridor from Ontario to Newfoundland. In this study, principal components analysis and average linkage clustering procedure were used to automatically classify distinctive synoptic categories based on the differentiations and similarities of meteorological characteristics between and within weather types. Meteorological data that was used in the analysis included hourly surface observations of air temperature, dew point temperature, sea-level air pressure, total cloud cover, wind speed/direction and occurrence of freezing rain as well as 6 atmospheric levels of 6-hourly NCEP-NCAR upper-air reanalysis weather variables of air temperature, dew point temperature, wind speed and direction for the winter months (Nov. - Apr.) of 1958/59-2000/01. The study area included 14 weather observing stations in Ontario, and 1 station in Montreal, Quebec.

Using the above procedures, 18 major synoptic types were identified for the selected 15 stations during the winter months (Nov.-Apr.) of 1958/59-2000/01. The statistical procedure was able to successfully identify 4-6 weather types most highly associated with freezing rain events in the study area. Four weather types (1-4) were most highly associated with freezing rain events at all selected 15 stations, while up to 2 additional weather types were identified at some of the stations. Using GCM outputs and statistical downscaling methods, discriminant function analysis was used to estimate the frequencies of freezing rain-related weather types in the future climate. Climate change scenarios from the Canadian GCM (CGCM1: 2041-60 and 2081-2100) and the U. S. GCM (GFDL R30 Coupled Climate Model: 2040-2059 and 2070-89) were used in the analysis. Preliminary results from the CGCM1 indicate that frequencies of the freezing rain-related weather types, over most of the study area, could increase from 1958-2000 to 2041-60. For example, in Ottawa, the freezing rain-related weather types are projected to increase by 19%. The corresponding frequencies of freezing rain occurrences are projected to increase by 16%, 32% and 49% for daily freezing rain duration of at least 1, 4 and 6 hours, respectively. The results are consistent with the historical relationships between monthly total freezing rain events and monthly mean temperature. The statistical procedure is being extended to the GFDL scenarios and to 2081-2100 for the CGCM1.

Session 1-D-2

The Atmosphere on Mars / L'atmosphère sur Mars

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Monday 2 June 2003
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1-D-2.1
Mars Atmosphere: on the Third Planet from the Sun
John McConnell
York University

Mars is one of the terrestrial planets but with smaller gravity than Earth or Venus which implies that gases may escape more readily. Its mean atmosphere pressure is 6 mb, roughly 150 times less than that of the Earth. The main atmospheric gas is CO2 (95.3%) with traces of N2 (2.7%), A (1.6%), CO (0.1%) and O2 (0.13%). Water is present in amounts determined to first order by the mean planetary temperature of about 220K. Even though there is more CO2 in the atmosphere than on the Earth, the greenhouse effect is much weaker due to the lower pressure with less line broadening (and of course much less water). One of the features of the Martian atmosphere that was evident even before it was visited by spacecraft was the occurrence, on a quasi-biannual (one Mars year) time scale, of vast dust storms that engulf the planet and rise so high that the tops of 25 km ancient volcanoes barely peak through. I will address, very briefly, some important topics such as the issue of the stability of the Martian lower atmosphere (potentially CO2 could be destroyed in about 2000 years), the movement of water throughout the atmosphere, the effects of the CO2 ice caps and the 30% changes in local surface pressure as the CO2 condenses and evaporates. We will also visit the upper atmosphere whose airglow is a source of structural and indirect dynamical information. Effective vertical mixing in the mesosphere/thermosphere region is some 100 times greater than in this region of the Earth. This talk serves two main purposes. One purpose is that it act as a rapid tutorial for a general audience of non-Martians and the other that several ideas and facts will be introduced so that the following speakers will not have to repeat!

1-D-2.2
Development of a Mars Spectral General Ccirculation Model
Youssef Moudden, Stephen Beagley, John C. McConnell, Ayodeji Akingunola, Antonio Garcia Munoz, Victor Fomichev
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Numerical modelling is an integral part in the study of the Martian atmosphere since it allows for the interpretation of the large set of data now available and helps to improve our understanding of Martian meteorology and climate. Starting from a dynamical core based on the CMAM (Canadian Middle Atmospheric Model), we have started to build a new CMAM (Canadian Mars Atmospheric Model) which is intended to be a GCM that goes from the surface to 200 km and beyond and which includes not only the most important components that determine the Martian climate but also thermospheric and ionospheric physics. The physics can, in part, be adapted from the current schemes in CMAM. Such is the case for surface fluxes, the PBL and the gravity wave drag. Many phenomena which do not have a ready equivalent in the Earth's atmosphere have to be represented in the model, especially the seasonal condensation of the CO_2 atmosphere in the Martian winter. This involves a large transport of mass and energy between the two hemispheres. Another crucial phenomenon is the regular large scale dust storms that can swallow the entire planet and cause severe change in the radiation budget. This phenomenon remains a puzzling one and the factors leading to its triggering are not completely understood. The talk will present the status of the model at the time of the conference.

Session 1-D-2

The Atmosphere on Mars / L'atmosphère sur Mars

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1-D-2.3
Modeling Dust and Clouds on Mars Using a One-Dimensional Aerosol Model
J. Pathak, D. Michelangeli and T. Fisico
York University

The interest in modeling Martian water ice clouds has recently been renewed given their likely involvement in both climate and hydrological cycle. Ground-based observations of Mars atmospheric temperatures, water, and aerosols have suggested that water ice clouds may regulate vertical distribution of dust and, hence, the global radiation balance, with strong seasonal forcing (Clancy et al., 1996). Previous related microphysical studies have already discussed the complex interactions between airborne dust and clouds (Michelangeli et al., 1993).

Water ice-clouds have been simulated on Mars with the help of a 1-d model. In order to effectively model clouds and dust in the Martian environment, a model capable of simulating microphysics, transport and radiation is required. We have modified CARMA, the Community Aerosol and Radiation Model for Atmospheres which is capable of simulating all these processes for this purpose. Preliminary results of this simulation exercise will be presented at the conference.

1-D-2.4
On Modelling the Martian Atmospheric Boundary Layer
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[2]*Dept. of Meteorology, University of Helsinki Finland*

Based on Savijarvi's (1999) Martian boundary layer model with a simple mixing length turbulence closure, high-order turbulence closure schemes are implemented. The model includes moisture and its hydrologic cycle is described.

Model results with different turbulence closures are compared with the diurnal cycle in the Mars Pathfinder sol 3-6 observed temperatures. The model processes concerning surface radiation and heat budgets, and the atmospheric radiative and turbulent heating rates will be discussed.

Reference
Savijarvi, H. 1999, 'A model study of the atmospheric boundary layer in the Mars Pathfinder lander conditions', Q. J. R. Meteorol. Soc. 125, 483-493.

1-D-2.5
Tides in the Martian Atmosphere: A Survey of Observations and Modelling
Charles McLandress,
Department of Physics, University of Toronto

Tides play an important role in the dynamics of the Martian atmosphere. In this presentation the mechanisms responsible for generating the tides are explained and compared to the situation on Earth. Observations and general circulation modelling studies of Martian tides are discussed.

1-D-2.6

The Mars Imager for Cloud and Aerosol (MICA) for the 2007 Mars Volcanic Emission and Life (MARVEL) Scout Proposal

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Recent images from the Mars Global Surveyor mission reveal a remarkable variety of water vapour and carbon dioxide condensate and aerosol structures in the Martian atmosphere. Some observations are recognisable as Earth-like polar low systems, cirrus or equatorial convective cloud belts while others appear to be new forms such as star-shaped clouds of orographic origin (Smith et al, 2002). Mineral aerosol sees remarkably large seasonal changes in optical depth and distribution culminating in dramatic global scale dust storms at irregular intervals.

The MARVEL mission proposes a new high resolution survey of Mars atmospheric constituents. The MICA instrument is one of three MARVEL instruments. While the other payload instruments are designed primarily to retrieve gas phase information, MICA will focus on detailed vertical distribution and optical properties of Mars condensates and aerosols through imaging the twilight limb. Correlated measurements during the extremely variable Mars dust cycle will allow the role of heterogenous chemistry in a planetary atmosphere to be studied in a fundamental way. MICA data will also be used to enhance our understanding of the atmospheric reservoirs and radiative forcings associated with Mars condensates and dust.

This paper will describe MICA science objectives and instrument concept. The imager design makes use of a novel occulting disc design to simultaneously observe both the sun and the aureole produced by aerosol scattering. It is being designed in collaboration with COM DEV Ltd and will be supplied to the MARVEL mission by the Canadian Space Agency.

This work is being supported by the Canadian Space Agency and Crestech.

1-D-2.7

Northern Light - A Canadian Mars Lander

Brendan M. Quine[1],
Northern Light Team,York University and Thoth Technology

We are developing a small Canadian lander and rover system to assist in the international effort to explore Mars and to provide niche science using Canadian technology. Northern Light is a complete entry, descent, and landing system equipped with sophisticated scientific instruments and experiments. This Canadian Mars lander will provide extensive new scientific information on the Martian surface, subsurface, and atmosphere. Northern Light is being developed by a public-private consortium of organizations led by Thoth Technology.

Our lander's science goals will include the search for water, the investigation of the atmosphere and radiative balance, the search for life, the characterisation of the Martian surface environment, and preparation for human presence and sample return. In this presentation, we discuss the Northern Light

concept and present an overview of the proposed mission. We describe our system, the instrumentation, and our science objectives.

1-D-2.8
Lidar Applications for Mars Atmospheric Studies
A. I. Carswell [1], A. Ulitsky [1], V. I. Podoba [1], D. V. Michelangeli [2], D. Lyons [2], P. A. Taylor [2], Wensong Weng [2] and M. Daly [3]
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Lidar (laser radar) systems have been developed to a high level of performance and are now the instrumentation of choice for a variety of terrestrial atmospheric measurements. In recent years the application of lidar technology for use in space has also been moving ahead. Since 1999 a team of Canadian scientists and engineers has been involved in the development and application of lidar systems for studies of the Martian atmosphere. This team has been part of the NASA MATADOR program aimed at developing instruments needed to measure the Martian atmosphere from a lander platform. The focus of MATADOR was on the dust devils that are such a common feature of the atmosphere on Mars. These dust devils not only dominate many of the atmospheric properties but also play a significant role in the properties and evolution of the Martian surface. Lidar offers the potential to remotely observe a variety of aspects of the Martian environment including the 3-D optical properties of the atmosphere. The atmospheric extinction, optical thickness and boundary layer height can be determined as well as the location and distribution of ice and dust clouds.

Lidar observations of dust devils can provide information on the structure and motion of these complex dynamical structures with high spatial and temporal resolution. The lidar backscattered signal contains a species specific Raman component as well as the elastic Mie and Rayleigh scattering. The Raman signal intensity is typically quite weak but in some instances this method can be successfully used for remote atmospheric measurements. Increased sensitivity of detection can be obtained by using the Differential Absorption Lidar (DIAL) technique. By using lidar wavelengths selected to probe the absorption spectra of particular species it is possible to measure their concentration with high sensitivity.

To test lidar capabilities in atmospheric conditions similar to those on Mars, prototype lidar instruments were used in MATADOR field studies carried out in the desert near Tucson in June of 2001 and 2002. Two lidar systems were used in the field test program to obtain information on atmospheric turbidity, boundary layer height and dust devil properties. The results obtained show clearly the lidar capabilities to provide detailed quantitative information on important properties of the Martian atmosphere at ranges out to several kilometers. The success of these initial field measurements has contributed to the inclusion of a Canadian Lidar in the PHOENIX program, accepted by NASA and CSA as a Phase A Study in the NASA SCOUT program. This paper presents an overview of the activities in these programs.

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Road Weather Systems / Systèmes météo route

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1-D-3.1
Developing an RWIS Network for Alberta's National Highway System
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In support of the proposal for a national network of Road Weather Information Systems (RWIS) across Canada, Alberta Transportation commissioned an ITS study in 2001 that includes an RWIS Network Deployment Plan for Alberta's National Highway System (NHS). From discussions held between all the provinces' representatives at the working group sessions, a station distribution formula was agreed-to based on each province's winter severity, the density of the network and the budget availability from Transport Canada. For Alberta, the maximum number of stations on the NHS that may become part of this national network is 70. The RWIS consultant used an innovative methodology that combines the road maintainers' knowledge, meteorological information, other relevant environmental and geographical data, traffic and safety data, and multi-jurisdictional station data, into a GIS (Geographic Information System) model of the provincial network.

The first step in the Network Design was to identify important stakeholders within and outside of Alberta Transportation that may be impacted or may contribute to this RWIS network. Once user needs were identified training sessions were held to assist many of the primary road maintenance users who had minimal exposure to RWIS and ITS. The AT and contractor representatives then developed a list of candidate RWIS sites covering the NHS. These candidate sites were reviewed using the GIS model to evaluate their suitability from a macro perspective to ensure they would be regionally representative. The final phase of data gathering include on-site micro-surveys of the potential station sites followed by analysis of the site information to ensure the placement of the equipment and sensors was suitable and data communicated to the server is truly representative of conditions from the site.

A key criteria in developing this GIS decision support model is to ensure a balanced view of road conditions; that is, include problematic "hot spot" sites and also, a number of "trigger sites" that represent the conditions for a larger area. The model is designed to identify contiguous segments having similar maintenance requirements by identifying the features (Topography, Vegetation, Meteorology, traffic volumes, proximity to water) which affect the degree to which road maintenance is required.

The proposed RWIS architecture has been developed in accordance with the ITS Architecture for Canada which will facilitate data exchange to existing legacy systems and to other ITS systems. The RWIS network may be able to feed relevant information to potential ATIS (Advanced Traveler Information System) and ATMS (Advanced Traffic Management System) for Highway 2, with the result that drivers will benefit from having real-time road and weather information. The Alberta RWIS network model will serve as a blueprint for any future expansion of the network should Alberta Transportation chooses to fill in gaps from other parts of the province.

1-D-3.2, 3
The Winter Road Maintenance Decision Support System (MDSS) Project Overview and Current Status
William P. Mahoney & William Myers
National Center for Atmospheric Research, Boulder

The U. S. Federal Highway Administration (FHWA) Office of Transportation Operations Road Maintenance Management Program began an initiative in 2000 to gather surface transportation weather decision support requirements from State DOT personnel. In addition, the Office of Federal Coordinator for Meteorology (OFCM) together with the FHWA, co-sponsored symposiums on Weather Information for Surface Transportation (WIST), which led to the development and publication of the U. S. national needs assessment report on surface transportation weather.

Utilizing information obtained from these activities, the FHWA began a project in fiscal year 2001 to develop a prototype winter road Maintenance Decision Support System (MDSS). The MDSS project goal is to develop a prototype capability that capitalizes on existing road and weather data sources, fuses data to make an open, integrated and understandable presentation of current weather and road conditions, generates diagnostic and prognostic maps of road conditions and provides a decision support tool that generates recommendations on road maintenance courses of action together with anticipated consequences of action or inaction.

Primary components of the MDSS include: a) a numerical weather prediction system, b) a road weather forecast and data fusion system, c) a road temperature model, d) road chemical concentration algorithms, and e) display system. The MDSS provides decision makers with explicit information on current and predicted weather and road conditions for user defined locations along plow routes. The system also provides decision guidance based on standard practices for effective winter road maintenance (e. g., anti-icing, deicing, plowing, etc.).

After the 2001 user needs assessment was completed, the MDSS program was extended into 2002 and 2003 with the objective of developing and demonstrating a functional prototype MDSS and releasing the prototype technology on a non-exclusive basis to the surface transportation community. A field demonstration of the MDSS occurred in Iowa between February and April 2003. The objective of the field demonstration was to evaluate the maturity level of the prototype and to identify items that required further development.

The presentation will describe the current status of the MDSS project, preliminary results of the winter 2003 field demonstration, and future implementation plans.

1-D-3.4, 5

The Winter Road Maintenance Decision Support System (MDSS) Road Condition And Treatment Module (RCTM)*

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Winter storms, with their accompanying snow, ice, wind, and freezing temperatures, have a significant impact on roadway safety and efficiency. Weather related roadway accidents account for over 7,000 fatalities and some 200,000 casualties annually in the United States. Additionally, combined state and local winter road maintenance costs exceed 2 billion dollars annually. Over the past decade, weather researchers have delivered significant improvements in the availability, volume, and quality of the sensors and technology utilized to both capture the current state of the atmosphere and generate weather forecasts. New radar systems, automated surface observing systems, satellites and advanced numerical models have all contributed to these advances. However, the practical application of this new technology for road transportation decision makers has been limited.

Winter road maintenance personnel require both an accurate forecast of the expected road conditions and guidance on recommended remedial action (e. g. applying chemicals or adjusting traffic flow). The FHWA (Federal Highway Administration), in conjunction with the Office of Federal Coordinator for Meteorology (OFCM), has worked to define the weather products needed by winter maintenance personnel. The FHWA determined that operators were in need of a weather forecast system that provides them both an integrated view of their weather, road and crew operations and advanced guidance on what course of action might be required. As a result, the FHWA has funded a consortium of national laboratories to prototype an integrated winter road Maintenance Decision Support System (MDSS). The MDSS uses state-of-the-art weather and road condition forecast technology and integrates it with FHWA anti-icing guidelines to provide guidance to winter maintenance operators in planning for and managing winter storm events.

A key component of the MDSS is the Road Condition and Treatment Module (RCTM). The RCTM is designed to bridge the gap from ambient weather forecasts (temperature, precipitation, wind, etc.) to road condition forecasts (pavement temperature, snow depth, mobility, etc.) and ultimately to recommendations for chemical applications and/or snow plowing to keep the roads above a minimum level of service. The RCTM consists of five main components: road snow depth, pavement temperature, road mobility, chemical concentrations and rules of practice (recommended treatments). The initial version of the RCTM, when combined with the sophisticated MDSS weather engine provides an end-to-end prototype solution for winter maintenance operators. The prototype was run experimentally in Iowa this past winter providing valuable feedback on the system's overall strengths and weaknesses.

This paper will describe the overall architecture of the RCTM, the five main components of the system, and the lessons learned from this past winter's Iowa experiment. We will also discuss the potential future research and development directions of RCTM and the MDSS prototype and the desire to transfer this technology, as it is developed, to private corporations for widespread distribution.

*This work is sponsored by the Federal Highway Administration under Air Force Contract No. F19628-00-C-0002. Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the United States Government.

1-D-3.6

Fog: Impact on Road Transportation and Mitigation Options

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Governments around the world are pursuing the goal of zero highway and traffic fatalities. In this quest, all impacts on road safety need to be examined including weather. Fog is one such road hazard that can be particularly insidious, causing some of the most spectacular and gruesome crashes involving a large number of vehicles. Canadians tend to focus on winter impacts on road transportation but fog has a significant impact as well. It is associated with 45 fatal and over 1300 injury road accidents per year on average in Canada.

This paper will examine fog accident trends over the last decade in Canada as well as take a close look at trends in fog-related accidents around the world. A discussion of causes and trends in road transportation that could aggravate the situation will also be offered. The Canadian Architecture for Intelligent Transportation Systems will be used as a framework to examine possible mitigation options for poor or zero visibility situations while driving motor vehicles. A preliminary review of possible contributions from the meteorological community will be undertaken.

1-D-3.7

Wind Mapping for Canada with WEST

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Developing the renewable energies (including the wind energy) is a key element to the sustainable development of a country in the changing climate. Canada has huge wind resources, but the installation of wind farm is quite low. The first step towards the installation of a wind farm is to determine the area of strong wind, or *wind siting*. The traditional way of doing this is to install wind observation towers (or masts) at test sites spanning an area as large as 100x100 km2 or more. It can take a year or more for a site to be chosen, equipment to be installed, then another multi-years for data collection and analysis.

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A wind mapping and forecasting tool, *WEST* (Wind Energy Simulation Toolkit), has been developed at the Meteorological Service of Canada. It is based on the statistical analysis of last fifty years of weather data and a limited area atmospheric model, MC2. This software can be used to produce high resolution wind map over large region, even in areas where no mast measurements are made. It can be run on a stand-alone laptop, a cluster of PCs, or a supercomputer, making it cost-effective for small environmental consulting companies to adopt. The WEST system will reduce the process of wind siting to about three months with much less costs.

It is now possible to create a modern high resolution wind atlas for the whole country, which will be available the public. Great interests have been raised within different government agencies, in particular the Environment Canada and Natural Resources of Canada. The national wind atlas, which has a spatial resolution of about 5 km for the whole country ranging from the Arctic to the U. S. border, will be available to industry sometime in 2004-2005. The wind mapping strategy, its impacts, and some preliminary results will be presented at the conference.

Session 1-D-4

Surface Ocean – Lower Atmosphere Study 3 / Surface de l'océan – étude de la basse atmosphère 3

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1-D-4.1

SERIES - Influence of Iron Fertilisation on DMS Production: An Unexpected Twist to the Ocean-Climate Connection

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In July 2002, a 64 km^2 area of the North-East Pacific (Long: 50°12; Lat: 144°45) was enriched with iron in order to determine the influence of this limiting micronutrient on the dynamics of climate relevant gases (CO_2, DMS and halocarbons). The fertilised patch was sampled for 25 consecutive days by three ships: J. P. Tully (Canada), El Puma (chartered from UNAM, Mexico), and the Kaiyo-Maru (Japan). Previous iron fertilisation experiments resulted in an increase in DMS concentrations, suggesting that iron addition may have a cooling effect on climate. Results from our iron fertilisation experiment show that adding iron may actually reduce DMS production and emission to the atmosphere and thus exacerbate global warming. The addition of iron first resulted in an increase in flagellates abundance and DMS concentrations, but DMSP and DMS levels decreased sharply when the iron-induced diatom bloom began. DMS concentrations per square meter were consistently lower (up to 3 times) in the iron-induced diatom bloom than outside the bloom. The influence of iron fertilisation on oceanic DMS production is thus more variable than previously reported, variability that will need to be taken into account in our attempts to model past and future climate.
Session preference: SOLAS, Oral

1-D-4.2

Determination Of Apparent Quantum Yield Spectra For Photosensitized Degradation Of Dimethylsulfide (DMS) In Northeastern Subarctic Pacific Ocean

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Photochemical reactions in the ocean could significantly impact the biogeochemical cycling of dimethylsulfide (DMS). DMS is the major oceanic source of reduced sulfur to the atmosphere, and it has been hypothesized that marine DMS emissions are involved in the biological regulation of global climate. However, despite extraordinary progress on the understanding of the global biogeochemical cycling of DMS in the past 20 years, the kinetics and mechanisms of DMS photochemistry in surface seawater remains uncertain.

In this study, polychromatic irradiation experiments were conducted to determine the wavelength dependence of DMS photodegradation apparent quantum yield (AQY) in marine waters. Using measured irradiance values for sample spectral absorption coefficient and DMS loss rate, the apparent quantum yield spectra for each irradiation experiment was calculated with a statistical fitting function (Cullen and Neale, 1997). Surface water samples were collected in the in the Northeastern subarctic Pacific Ocean aboard B/O El Puma in July 2002, during the Subarctic Ecosystem Response to Iron Enhancement Study (SERIES), as part of the Canadian Surface Ocean Lower Atmosphere Study (C-SOLAS) network. In July 2002, a 64 km^2 patch of ocean was iron-fertilized near Ocean Station Papa (50^oN and 145^oW).

The salient findings of this study will be presented: 1) Apparent quantum yields of DMS photodegradation decrease exponentially with increasing wavelength in the UV yielding a broad solar response curve between 300 and 360 nm with a maximum response centered at approximately 330 nm. 2) DMS photodegradation rates were lower within the iron-fertilized patch than in the surrounding waters. 3) Most (95%) of the DMS photodegradation occurred in the top 10 m of the water column. 4) DMS photodegradation rate measured in water collected at 1500 m depth is about 5 times higher than rates measured in surface waters.

In addition, mechanistic aspects and environmental controls of DMS photodegradation rates were examined using full spectrum irradiation experiments. Results will lead to a better quantitative

understanding of DMS photochemistry in the surface ocean and greatly improve our ability to assess the DMS sea-to-air flux.

1-D-4.3

Trends in Atmospheric Dimethylsulphide During SERIES

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[3]*Meteorological Service of Canada, Downsview, ON*

Iron is a limiting nutrient in many parts of the world oceans. Various experiments have been carried out in these areas to simulate natural, aeolian additions of iron to observe their effects on phytoplankton productivity. In July, 2002 an iron enrichment experiment (SERIES) was carried out in the sub-arctic Pacific Ocean as part of Canadian SOLAS. One of the hypotheses to be tested was that iron enrichment would stimulate the production of DMS, resulting in enhanced surface DMS concentrations and sea-to-air flux of DMS. Atmospheric DMS measurements were made hourly beginning on Day 4 of SERIES (July 13) and continuing through Day 19 (July 28). Samples were collected from the bridge deck of the research vessel El Puma by drawing 1 litre of air through TENAX-filled borosilicate tubes. Samples were kept frozen and analyzed within 24 hours of collection. The DMS was thermally desorbed onto the column of an HP 5890 gas chromatograph equipped with a sulphur chemiluminescence detector. In general, the iron addition stimulated production in DMSP lyase-using phytoplankton communities (i. e. flagellates). This resulted in an increase in DMS in the surface water column, accompanied by an increase in atmospheric DMS. This was followed by a change to a more diatom-rich phytoplankton community, characterized by less DMS production. Concentrations of DMS throughout SERIES were relatively high, ranging from 0.1 to 8 ppbv. Lower concentrations were measured near the beginning and end of the experiment with higher concentrations measured between Days 11 and14. The maximum atmospheric concentrations were associated with a surface ocean ventilation episode caused by high winds. Concentrations were often (but not always) higher in the air above the "patch" compared to areas outside of it, and there was some evidence of diurnal variation.

1-D-4.4

Sulphur Dioxide, Aerosol Sulphate and Methanesulphonic Acid During SERIES

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Sulphate and methanesulphonic acid (MSA) form fine aerosols in the atmosphere that scatter incoming solar radiation back to space and act as cloud condensation nuclei. These factors make atmospheric sulphur compounds key components to describing the global radiation budget. The ocean is a major source of atmospheric sulphur. Iron fertilization of the ocean's surface through additions of aeolian dust has been postulated as an important feedback mechanism in global climate. As the number of micro-organisms in the ocean's surface increase in response to iron fertilization, an increase in the gaseous sulphur compound dimethylsulphide (DMS) is expected. DMS is released by phytoplankton assemblages in surface waters. A portion of this gas escapes to the atmosphere and undergoes oxidation to sulphur dioxide and subsequently to sulphate and MSA. The ratio of heavy to light sulphur isotopes are distinctive for many ocean and continental sulphur sources and can be used as markers for biogenic sulphur from DMS oxidation.

Preliminary results from an atmospheric sulphur sampling program downwind of the iron enrichment experiment (SERIES) that took place in July, 2002, as part of the Canadian SOLAS will be presented. High volume samplers were mounted on board the upper deck of the research vessel El Puma and were used to collect "in patch" and "in or downwind of patch" aerosols and sulphur dioxide. A second set of samplers were stationed on the roof of the Canadian Coast Guard station at Ucluelet on

Vancouver Island. The land-based samplers were computer controlled to operate only during periods when winds above 1 km/hr from the SERIES experiment were in sector. The results for sulphur dioxide were intriguing: the most positive $\delta^{34}S$ values (indicative of DMS-oxidation) were found upwind of the fertilized patch. However, it was not surprising to see that higher $\delta^{34}S$ values corresponded to more sulphur dioxide in air aboard the ship.

1-D-4.5
Characterization of Aerosol Over the North Pacific
Lisa Phinney [1], Richard Leaitch [2], and Ulrike Lohmann [1]
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Atmospheric measurements were taken in the North Pacific on board the ship El Puma in July 2002 as part of the SOLAS Sub-Arctic Ecosystem Response to Iron Enrichment (SERIES) study. A Differential Mobility Analyser (DMA), Passive Cavity Aerosol Spectrometer Probe (PCASP) and Forward Scattering Spectrometer Probe (FSSP) were used to measure aerosol size distribution. Also on board were filters that have been analysed for organic species, and a Multiple Orifice Uniform Deposit Impactor (MOUDI) to measure size-resolved inorganic species. An Aerodyne Aerosol Mass Spectrometer (AMS) was used for the first time in a true marine environment to measure the mass concentrations and size distributions of particulate sulphate, nitrate and organic species. The data have been examined for mass closure for the aerosol over the North Pacific. Preliminary analysis shows good agreement between MOUDI mass loadings and total aerosol volume as given by the DMA and PCASP, and good agreement between these data and the AMS. Average total mass loading measured by the AMS is 1.8 $\mu g\ m^{-3}$, and is comprised of 1 $\mu g\ m^{-3}$ sulphate and 0.7 $\mu g\ m^{-3}$ organics. Nitrate and ammonium are much lower. This project marks the first time that atmospheric measurements have been included in an iron-enrichment campaign. Background aerosol measurements, taken outside the iron-influenced area, provide a characterization of the North Pacific aerosol, while the iron-influenced area may provide an increased dimethylsulphide (DMS) source from which to investigate the conversion of DMS gas to sulphate aerosol. Measurements of DMS and sulphur dioxide (SO_2) gasses were obtained during the cruise, and the conversion process is investigated in two case studies -- an East-West transect on July 25, and a similar transect on July 27. Meteorological data were also collected and together with ship log data will aid the analysis.

1-D-4.6
Optical Properties of Aerosol Particles over the Northeast Pacific
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In July of 2002 atmospheric sampling took place over the northeast Pacific Ocean as part of the Sub-Arctic Ecosystem Response to Iron-Enhancement Study (SERIES). The size spectra of aerosols were measured over a range of diameters from 0.0075-47.0 micrometres, using a scanning mobility particle system (SMPS), a passive cavity aerosol spectrometer probe (PCASP) and a forward scattering spectrometer probe (FSSP). The chemical composition of the aerosols was measured by filter analysis; quartz filters for organic constituents and teflon Multiple Orifice Uniform Deposit Impactor (MOUDI) filters for inorganic constituents. Further data on both size distributions and chemical composition were collected by the Aerodyne Aerosol Mass Spectrometer (AMS). The absorption coefficient of the aerosols was measured with a Particle Soot Absorption Photometer (PSAP), and the scattering and backscattering coefficients of the aerosols were measured with an integrating nephelometer. The problem of optical closure is considered, whereby the optical properties of the aerosols are measured by one method and compared with model predictions based upon independent measured quantities. To that end the observed size spectra and chemical compositions are combined with Mie scattering theory, and these predicted scattering, backscattering and absorption coefficients are compared with the observations from the nephelometer and PSAP. In particular, the scattering contributions of the coarse mode aerosols, dominated by sea salt, are compared with scattering from

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smaller particles. Limitations of the nephelometer with respect to measuring forwardscattering from large particles may be responsible for some of the disagreement between the calculated and observed scattering coefficients.

1-D-4.7
Stronger Constraints on the Anthropogenic Indirect Aerosol Effect
Ulrike Lohmann, Glen Lesins and Yiran Peng
Dalhousie Univeristy

The anthropogenic indirect aerosol effect of modifying cloud albedo and cloud lifetime cannot be deduced from observations alone but requires a modeling component. Here we validate a climate model, with and without indirect aerosol effects, by using satellite observations. The model agrees better with observations when both indirect aerosol effects are included. However, the simulated clouds are more susceptible to aerosols than the observed clouds from the POLDER satellite, thus overestimating the indirect aerosol effect. By taking the difference in susceptibilities into account, the global mean anthropogenic aerosol effect is reduced from -1.4 W/m^2 to -0.85 W/m^2. Half of this discrepancy is eliminated when the effect of the dispersion of the cloud droplet size distribution on the indirect aerosol effect is taken into account.

1-D-4.8.01
Air-Sea Flux of CO_2 in the Labrador Sea
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Deep convection in the Labrador Sea characterises a unique and important process of air-sea flux of CO_2. The Labrador Sea is one of two sites in the North Atlantic that produces intermediate and deep water by winter convection. During convection, CO_2 is taken up in the surface water and is quickly transported to the depth over few hundred meters and in extreme years over two thousand meters. Sequestered CO_2 is subsequently incorporated into the meridional overturning circulation and stored in the deep ocean. Thus, it is important to monitor and understand the size and variability of the CO_2 sink associated with deep convection in the Labrador Sea to assess the global carbon cycle. We have conducted a time series study of total inorganic carbon, alkalinity, oxygen and nutrients since 1993 and CFCs since 1991 along the WOCE AR7W section as well as a one-time survey of over 100 stations covering large area in the Labrador Sea in 1997. The total inorganic carbon inventory in the Labrador Sea was 106±14 G ton C in 1997. We observed deep convection in the Labrador Sea in early 1990's (>2000m), followed by shallow convection (500-1000m) and convection became deeper again in 2000 (~1200m). During deep winter convection, atmospheric gasses such as CFCs are incorporated into the surface water and efficiently sequestered to the depths. As a result, the inventory of these anthropogenic gasses increased faster during deep convection than shallow convection period. Determining carbon dioxide sequestration is more complicated, because deeper water with higher total inorganic carbon is mixed with surface water during deep convection. As well, the nutrient flux to the surface may enhance surface productivity. The time series study of total inorganic carbon and estimated biological component carbon (respiration and calcium carbonate formation and dissolution) will be compared for shallow and deep convection regimes.

1-D-4.8.02

The Response of Mezooplankton to Enhanced Primary Production during the SOLAS-SERIES Experiments

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Biology Department, University of Victoria

As part of the SOLAS-SERIES experiments in July 2002, we investigated potential mezooplankton responses to an iron-mediated phytoplankton bloom in the subarctic Pacific HNLC region. Zooplankton net samples were removed from depths corresponding to the mixed layer and 150m, both within and outside of the iron-fertilized patch. Preserved samples were used to determine potential changes in the species composition, abundance and biomass in response to increasing phytoplankton abundance. The activity of the crustacean moulting enzyme chitobiase was assayed in the water column. The rate of decay of chitobiase in water samples free of crustaceans represents the rate of turnover of the crustacean zooplankton community as a whole. Thus we attempted to estimate the extent to which zooplankton growth (and production) responded to enhanced primary production. Preliminary results suggest that relative copepod species abundance and biomass remained unchanged during the course of the experiment. A significant chitobiase decay rate was assayed in the water column and growth rate estimates will be discussed.

1-D-4.8.03

UV Optical Properties during the Evolution of a Phytoplankton Bloom

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Photochemical oxidization of coloured dissolved organic matter (CDOM), which plays an important role in the carbon cycle, is initiated by the absorption of ultraviolet (UV) radiation. Products of this oxidation include carbon dioxide, carbon monoxide, hydrogen peroxide and radicals, which facilitate dimethylsulfide loss in the photic zone. The in situ UV optical properties were measured in the NE subarctic Pacific at Ocean Station Papa during July 2002 during the evolution of a tagged phytoplankton bloom resulting from a purposeful addition of Fe. Two optical instruments were deployed at each of 22 stations over 19 days. A Satlantic SeaWiFS Profiling Multichannel Radiometer measured the downwelling irradiance (Ed) at depth in thirteen channels centered on the following wavelengths: 305, 323, 338, 380, 412, 443, 490, 510, 532, 555, 670, 683 and 700 nm. A Satlantic Ocean Colour Radiometer (OCR) simultaneously provided a surface reference by measuring incident downwelling irradiance just above the ocean's surface in the same thirteen wavebands plus 590 nm. The OCR also measured upwelling radiance (Lu) within a few cm of the water's surface in the same fourteen channels for correlation to remotely sensed ocean colour. CDOM, the main component responsible for UV attenuation in the ocean, was also measured in water collected at each station. Obvious changes in visible light attenuation due to phytoplankton growth were also seen in the UV profile data but less so in CDOM measurements. Using these data to examine spatial and temporal changes in UV spectral characteristics, quantitative relationships among phytoplankton bloom dynamics, CDOM absorbance spectra, UV attenuation, and DOC concentrations will be examined.

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Session 2-A

Plenary / Plenière

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2-A-1
"Forecasting the Nation's Health" - the UK Met Office Experience in Predicting Daily Workload in the British Health System
William Bird
Health Forecast Unit, UK Met Office

For the past 2 years, the UK Met Office has been carrying out a program entitled "Forecasting the Nation's Health". The goal is to use weather and climate information along with infectious disease reports to help predict fluctuations in workload within the National Health Service, thereby helping the System and the professionals within it better manage the limited resources.

Using principally research which established links between temperature decreases and presentations for heart attacks (peaking 2 days later) and respiratory problems (peaking 12 days later), the resultant workload pressures on the doctors, clinics and hospitals is modelled. The first winter pilot saw 5 hospitals participating. This past winter, 30 regions, including 28 hospitals, 26 GP co-ops and some call centers, participated. During this winter of 2002-2003, a numerical model is in use and real time health data is being collected from a population of over 20 million. Each hospital has the actual number of admissions predicted y the model with confidence limits for up to 10 days ahead.

Funded by the British Treasury, working with the Department of Health, with the hospitals, medical associations and university colleagues, the UK Met Office team issues daily 10 day forecasts. Initial calculations of accuracy of hospital admission forecasts for the third winter appear more accurate than the previous winters. The verification statistics for the second winter indicated 65% accuracy in forecasting workload changes -considerably better than the 55% accuracy of the first winter.

In surveys of participants, 50% of the respondents in the second year indicated that they acted on the information provided. This was an increase over the usage in the first year, presumably as user confidence in the product grows Such actions included not carrying out planned staff increases when the forecasts suggested that this would not be necessary or vice versa, increasing staffing, for example over a weekend, when workloads were predicted to rise. And the most dramatic report was from the Royal Berkshire Hospital which indicated that it performed 150 more elective surgeries than planned on the strength of a quiet emergency workload forecast in the December of pilot year 1, thereby improving service to patients on waiting lists while avoiding a potential bill of £ 400K for diversion of the operations to the private sector.

The presentation will describe how and why the UK Met Office initiated this service, how the program works, how the predictions verify and, most importantly, how this product impacts the user community (the Health care system and professionals) and their clients (the patients).

2-A-2
Climate Change Impacts and Adaptation - DFO's Response to The Challenge
Wendy Watson-Wright
Fisheries and Oceans Canada

Climate change scenarios show the vulnerability of resource-based communities, including fisheries. They also show that the greatest impact will be in the North, where temperature increases will have a significant affect on ice, Arctic waters and coastlines and the people and marine life that live there. Canada's Department of Fisheries and Oceans recognizes the challenges ahead to understand these changes, and act to minimize their effect on the marine environment. We are collaborating with various partners to develop and improve coupled modeling capability, and to bring this down to regional and local scales that will be useful for mitigation planning. We are focusing on increased and sustained monitoring to better understand the changes in the longer term.
Adaptation to a changing climate may require flexibility in the fish resources Canadian fishers draw from the sea, and and may lead to increased aquaculture as a means to sustain economic activity. Shipping lanes and channels may suffer from reduced water outflow from the Great Lakes, which will

bring a call for increased monitoring and reporting, and possible changes in shipping practices. Rising sea levels require that vulnerable areas be protected, and that forecasts of and preparation for storm surges that could bring increasing impacts are made. The potential opening of a shipping channel in the Arctic may bring increased calls for ecosystem management, oil spill response, search and rescue services in harsh conditions, and improved hydrographic charts.

2-A-3
Measurements of Chemical Constituents in the Stratosphere from Balloon-Borne and Ground-Based Instruments
Kimberly Strong
Department of Physics, University of Toronto

Stratospheric ozone is well known to be a highly effective absorber of harmful solar ultraviolet radiation. This absorption serves as the dominant source of heating in the stratosphere, in turn influencing stratospheric winds. Stratospheric ozone concentrations have declined significantly since about 1980, particularly in the polar regions, in response to enhanced levels of chlorine resulting from emissions of chlorofluorocarbons. During the 1990s, springtime losses in lower stratospheric ozone have frequently been observed over the Arctic, but long-term trends in Arctic ozone can be difficult to distinguish from meteorological variability. At mid-latitudes, ozone columns over Canada have decreased by about 6% in the last 20 years. Although the basic mechanisms for polar and mid-latitude ozone loss are generally understood, there are still some discrepancies between models and observations. In addition, over the next few decades, while the expected slow recovery of the ozone layer is occurring, changing greenhouse gas concentrations will continue to alter the chemical balance of the stratosphere. In order to provide the scientific understanding of this changing chemical balance and its impact on the stratospheric ozone budget, measurements of seasonal, latitudinal, and vertical variations in mid-latitude ozone and related trace gases are required. For this purpose, we are involved in using both balloon-borne and ground-based instrumentation to measure chemical constituents over Canada. This presentation will describe three such projects.

The first is the MANTRA (Middle Atmosphere Nitrogen TRend Assessment) series of high-altitude balloon flights. Three balloons have been launched to date, in 1998, 2000, and 2002, all from Vanscoy, Saskatchewan (52°N, 107°W). Each carried a suite of instruments to measure vertical profiles of stratospheric trace gases from a float altitude of about 35 km for one day. Several of these instruments were flown by Environment Canada 15-20 years ago, providing a link to historical data predating the onset of mid-latitude ozone loss. The resulting measurements are being used to investigate changes in the concentrations of mid-latitude stratosphere, with a focus on nitrogen compounds. This talk will provide an overview of the MANTRA project and the results to date.

We are also studying the mid-latitude stratosphere at the recently established University of Toronto Atmospheric Observatory (TAO), located at 44°N. The primary instrument at this facility is a high-resolution Fourier transform infrared spectrometer. It is used to record solar absorption spectra, from which total columns and vertical profiles of many trace gases can be derived. We are currently analysing our first year of data, and some of our initial results will be presented.

The third project to be discussed is the use of a ground-based UV-visible grating spectrometer in the Arctic. This instrument has been deployed on five Arctic field campaigns between 1999 and 2003: four at Environment Canada's Arctic Stratospheric Ozone Observatory (ASTRO) at Eureka (80°N) and one at Resolute Bay (75°). At these locations, it has been used to measure ozone and NO_2 total columns, as well as NO_2 vertical profiles, during the crucial winter/spring period when the perturbed conditions leading to chemical ozone depletion occur. Again, the instrument will be briefly described and data from the Arctic campaigns will be reviewed.

Session 2-A

Plenary / Plenière

Chair / Président :
Savi Narayanan

Tuesday 3 June 2003
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Room / Salle
Ballroom B & C

Session 2-B-1

Impacts of Weather (land and ocean) and Climate on Society / Les impacts du temps (terre et mer) et du climat sur la société

Chair / Président : Eric Taylor

Tuesday 3 June 2003
mardi 3 juin 2003

Room / Salle Pinnacle

2-B-1.1
Scenarios of Climate Change for Impacts and Adaptation
Elaine Barrow[1], Philippe Gachon[2]
[1]*Canadian Climate Impacts Scenarios (CCIS) Project, Environment Canada - PNR*
[2]*Adaptation and Impacts Research Group, Environment Canada at Ouranos*

Climate change scenarios are one of the main requirements of any climate change impacts assessment. The Canadian Climate Impacts Scenarios (CCIS) Project constructs and disseminates scenarios of climate change according to criteria recommended by the Intergovernmental Panel on Climate Change Task Group on Scenarios for Climate Impact Assessment. These scenarios, related information and advice are available to the impacts and adaptation community in Canada. This presentation will discuss the reasons for using climate change scenarios, the different methods of scenario construction and application, as well as some of their limitations. Examples of the most recent climate change scenarios for Canada will be given. In addition, efforts which are underway to construct scenarios of climate variability and extremes will be outlined.

2-B-1.2
Preventing Extreme Weather Events from Becoming Disasters
Paul J. E. Kovacs
Institute for Catastrophic Loss Reduction, University of Western Ontario

Worldwide, natural disasters killed more than 650,000 people during the 1990s. More than 2 billion people were affected directly, including evacuation of their homes, and property damage exceeded C$1 trillion. Disaster payments by insurers, governments and international aid organizations have been doubling every 5 to 7 years since the 1950s, and alarming and unsustainable international trend. Perhaps the greatest tragedy is that many disaster losses are preventable. Investment in protective infrastructure, improvements in land use planning, enforcement of building codes, extreme weather research, public education and other adaptive measures can reduce or eliminate the adverse impact of hazards. This presentation will assess the factors contributing to rising disaster losses and society's capacity to be more effective in disaster prevention through increased investments in adaptation to weather extremes, including a focus on the role of the insurance industry.

2-B-1.3, 4
Climate and Health Issues in the Toronto-Niagara Region: Assessing the Implications of Climate Change for Health Infrastructure
Quentin Chiotti
Pollution Probe

Although health and climate have been associated for centuries, there is still much uncertainty regarding the specific impacts of the current climatic environment upon the health of individuals in many regions of the world. This knowledge gap is especially problematic when assessing the potential impacts of climate change, both in terms of projecting health effects and the adaptive capacity of health infrastructure. Drawing upon a three year study led by Pollution Probe, in partnership with Federal, Provincial and local agencies, this paper presents an assessment of the implications of climate change for health infrastructure in the Toronto-Niagara region. The paper is organized into five sections. In section one, the discussion outlines the divergent and somewhat contradictory perspectives in the scientific literature about weather, climate change and health as it applies to the Canadian situation. Section two presents an assessment framework for evaluating the relationship between climate (and climate change) and human health, which includes an ecological approach that considers the interactions between climatic stresses, changes in ecosystem function, and health outcomes. In section three, the discussion shifts its focus onto the local level, and describes the health effects from the current climatic environment in the Toronto-Niagara region, and the adaptation measures currently in use. Six health issues are examined: temperature extremes, extreme weather events, vector-borne and rodent-borne diseases, air pollution and indoor environments, water-borne and food-borne illnesses, and UV radiation. Section four outlines the implications for each of these six

health issues with projected climate change. The paper concludes by outlining an adaptation action plan consisting of 5 key steps: 1. Research on knowledge gaps and key questions that are meaningful to health stakeholders, 2. Monitoring and surveillance of key climate and health indicators needed to undertake the longitudinal analysis necessary for developing effective adaptation strategies, 3. Education activities aimed at the health care community and the general public, 4. Partnership building involving multiple stakeholders, and 5. Coordination of structures with responsibility for climate change and human health.

2-B-1.5

Impacts of seasonal variability and climate change on foodborne disease

Manon D Fleury [1], Dominique Charron [1], Abdel Maarouf [2], and David Waltner-Toews [3]
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[2] Meteorological Service of Canada, and York University, Toronto, Ontario
[3] University of Guelph, Guelph, Ontario

The incidence of enteric infections of people in Canada varies seasonally, and will therefore be expected to change in response to climate changes. In order to explore this possibility further, we investigated the potential shift in the seasonal patterns of the enteric pathogens *Salmonella, Campylobacter* and *E. coli*, in Alberta and Newfoundland between 1992 and 2000. Trend analysis of the effects of climate variability was accomplished using time series analysis with generalized additive and generalized linear models. The results reveal a significant increase in maximum temperatures and illness for both provinces. This increase is more pronounced in summer compared to winter months. Explanations may include seasonal variations in consumer behaviour, such as changes in the types of food consumed and methods of preparation (e. g. barbequing). However, it is also possible that the excess number of food poisoning cases in the summer is due to higher temperatures, promoting pathogen survival and replication in foods and increasing the incidence in animal reservoirs (Betham and Langford, 2001). Our results are consistent with the predictions that global warming may affect the pattern of gastro-intestinal disease cases in Canada.

2-B-1.6

Canadian Weather through the Eyes of Canadian Artists

Phil Chadwick
MSC

Canadian weather art through the eyes of plein air Canadian Artists - Featuring Tom Thomson. The passion of Canadian artists for weather will be illustrated with some examples. The impacts of artisits on Canadian Society will be briefly suggested.

Note: This is intended to be an entertaining look at the impacts of weather on artists and Canadian society. (please note that the length of this presentation can be whatever you want it to be - depending upon the number of paintings I use. There are lots. I also intend to put in some of my own work.)

http://philip.chadwick.homestead.com

Session 2-B-1

Impacts of Weather (land and ocean) and Climate on Society / Les impacts du temps (terre et mer) et du climat sur la société

Chair / Président : Eric Taylor

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Session 2-B-2

Climate and Climate Change 4 / Le climat et changement de climat 4

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2-B-2.1
Diagnosis of Simulated and Observed Extra- Tropical Cyclones
Steven J. Lambert
Canadian Centre for Climate Modelling and Analysis, Meteorological Service of Canada Victoria, B. C.

There are large uncertainties in climate model simulations of the behaviour of extra-tropical cyclones under enhanced Greenhouse warming. Since a variety of diagnostic techniques are used to analyse such simulations, it is possible that the analysis methods themselves, are contributing to the lack of agreement among models.

The ability of commonly used techniques to provide consistent basic measures of cyclone behaviour such as climatology, interannual variability, and trends when they are applied to the NCAR/NCEP Reanalyses are discussed.

2-B-2.2
Cloudiness Trends in Canada
Ewa Milewska
Climate Research Branch, Meteorological Service of Canada

Clouds play an important role in the total Earth's energy budget. Because of the complexity of physical processes associated with overall cloud formation, it is still not fully understood whether more or less clouds can be expected in the warmer climate. The rise in temperature should increase evaporation into the atmosphere, creating potentially favourable conditions for the formation of more clouds. However, higher atmospheric water vapour content may not directly lead to more clouds, because warmer air can hold more moisture before condensation occurs and clouds develop. The other factor indigenous to higher latitudes is that warmer temperatures mean prolonged seasons of open ice-free water available for evaporation. This would make Canadian regions prime candidates for the increase in cloudiness. Cloudiness trends in Canada are evaluated using 40 to 50 year long hourly observations from airport stations across Canada. Hourly observations are averaged over each year, seasons, daytime and nighttime hours. Trends are computed for annual time series. It may not be entirely possible to simply project observed trends into the future as changes in the cloud cover may also influence temperature trends.

2-B-2.3
Climatological Analysis of Northern Hemisphere Anticyclones
Lily Ioannidou and Peter M. K. Yau
Dept. of Atmospheric and Oceanic Sciences McGill University, Montreal

A global climatology of the Northern Hemisphere winter anticyclones is presented. The climatological estimates are based on the 14-year ECMWF Re-Analysis dataset that covers the 1979-1993 period and are obtained with a sophisticated model that tracks anticyclones through their lifetimes simultaneously over different parts of theglobe. The tracks' ensembles are subsequently submitted to objective analysis to generate global distributions of the anticyclones' properties such as their characteristic lifetimes, intensities, phase speeds and growth rates and also of the anticyclones' genesis, lysis and track distribution frequencies.

To quantify the contribution of different wavelengths to the observed total anticyclonic activity the global fields are then spectrally decomposed into a number of wavelength bands and the above analysis is repeated for each band. The results demonstrate the predominance/absence of certain wavelengths in some regions of the hemisphere. In other regions a relatively strong/weak contribution of certain wavelengths to the total anticyclonic activity is seen. The properties of anticyclonic development in the corresponding scales are estimated. The effect of the stronger or weaker contribution of certain wavelength bands in modulating the features and the frequency distributions of the anticyclones observed in a particular region are discussed. A way ofevaluating anticyclonic

development that accounts for the relative contributions of different wavelengths to the total development is proposed. Finally, interannual variations in the hemisphere's anticyclonic activity and regional variations in the anticyclones' vertical structure are viewed in the light of the information revealed by the decomposed results.

2-B-2.4
Oceanic Signatures and Long-Term Trends in the Climate over the Lower Mainland of British Columbia
Ruping Mo
Pacific Weather Centre, Environment Canada, Vancouver, BC

Daily maximum/minimum temperatures and total precipitation for 55 years (1948-2002) at two airports (Vancouver and Abortsford) are used to analyze the climate variations over the Lower Mainland of British Columbia (LMBC) under the influence of the Pacific Ocean. It is shown that the LMBC temperatures in both cold (October to March) and warm (April to September) seasons are significantly correlated with coastal sea surface temperature (SST) anomalies over the eastern North Pacific, which, in turn, are linked to the El Nino/Southern Oscillation (ENSO) in the tropical Pacific and SST anomalies in the extra-tropical North Pacific via the so-called "atmospheric bridge". During an El Nino event, anomalous southerly winds associated with a deepening Aleutian low advect warm moist air along the west coast of North America, leading to positive SST anomalies in the eastern North Pacific and warmer-than-normal conditions over the BC south coast. Signatures of the Pacific Decadal Oscillation may also be explained in a similar manner.

No significant correlation between the ENSO and the LMBC precipitation can be identified. It is possible that the dynamic effect of warm moist advection along the west coast of North America during an El Nino event is mitigated by dry outflow winds induced by positive surface pressure anomalies over Western Canada. Nevertheless, noticeable oceanic signature in the LMBC precipitation can be found over the western North Pacific (160E-180E, 40N-45N) in the cold season.

Further analysis has indicated that SST anomalies in that area can force a semi-circular wave train in the troposphere across the North Pacific. The associated teleconnection pattern, which partially resembles the western Pacific pattern defined by Wallace and Gutzler(1981), supports a positive correlation between those SST anomalies and the LMBC precipitation.

Trend analysis indicates that temperature has been rising and precipitation slightly increasing in the last 50 years or so over LMBC. In the cold season, the warming trends in the daily maximum and minimum temperatures are significant at the 95% confidence level, while the trend in the precipitation is negligible. In the warm season, a weakly increasing trend in the precipitation is echoed by a significant warming trend in the daily minimum temperature and a less significant trend in the daily maximum temperature.

2-B-2.5
Trend Analysis of Canadian Pan Evaporation Data
Ron Hopkinson
Prairie and Northern Region, Meteorological Service of Canada, Regina, Saskatchewan

Evaporation is an important part of the hydrologic cycle. There is an expectation that open water evaporation will increase as the season lengthens and air temperatures increase in association with climate change. Daily pan evaporation observations are available for a number of Canadian sites since the early 1960s and are stored in the Canadian climate archive. The observing program utilizes the class A evaporation pan which requires manual servicing once per day through the normal operating season. A thorough review of all the archived pan evaporation data revealed a number of gross daily errors usually associated with large precipitation events. The large erroneous daily values were replaced by more realistic values prior to attempting the trend analysis. Trend analysis was conducted for all of the long-term pan evaporation stations. There was no clear evidence, either regionally or

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nationally, of spatially consistent significant trends in pan evaporation in Canada. There is a tendency for decreasing pan evaporation on the southern prairies in July and also during the May to September season but even there, the trends are not all significant or spatially consistent. The conclusion was that either there were no real trends in pan evaporation between 1960 and 2002 or that the pan evaporation data were inadequate for the task in terms of record length and/or data quality.

2-B-3.1, 2
Modelling Of Chemical-Climate Coupling in the Middle Atmosphere
Theodore G. Shepherd
Department of Physics, University of Toronto

In the middle atmosphere there are strong feedbacks between chemistry, radiation, and dynamics. This is most evident in the case of ozone, which is sufficiently long-lived to be significantly affected by transport, yet not so long-lived as to be spatially homogeneous, thereby providing strong climate sensitivity. This talk will review some of the basic elements of chemical-climate coupling in the middle atmosphere, and illustrate the concepts in the case of ozone. A test of our scientific understanding is our ability to model this coupling from first principles, so I will also address the issue of chemical-climate model validation from this perspective.

2-B-3.3
SWIFT: The Stratospheric Wind Interferometer for Transport Studies
I. McDade[1], J. V. Lukovich[1], W. Gault[1], G. G. Shepherd[1], Y. Rochon[2], T. G. Shepherd[3], C. McLandress[3], R. Michaud[4] and T. Wehr[5]
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[2]*Meteorological Service of Canada*
[3]*Department of Physics, University of Toronto*
[4]*Canadian Space Agency*
[5]*European Space Agency ESTEC*

Central to a quantitative analysis of constituent and most notably ozone transport in the stratosphere is an understanding of the interplay between chemical and dynamical processes in this region. The Stratospheric Wind Interferometer for Transport Studies is a satellite instrument designed to address these issues by providing co-located wind and ozone profiles on a global scale. The instrument is currently being evaluated by the Canadian and European Space Agencies for possible launch in 2007 on a Japanese satellite. This talk will outline the scientific and observational objectives of the SWIFT mission which focus on stratospheric transport and tropical dynamics. An assessment of the expected instrument performance and the scientific impact of the measurements will be discussed.

2-B-3.4
The Canadian Middle Atmosphere Model : Results and Model Development
Jean de Grandpré
Université McGill

Middle atmosphere chemistry-climate models are complex and powerful tools which can be used to investigate coupled chemical-dynamical processes in various regions of the atmosphere from the surface to the mesopause region and beyond, as well as the coupling and feedback between different regions of the atmosphere which cannot otherwise be addressed. The Canadian Middle Atmosphere Model (CMAM) incorporates a prognostic and interactive ozone field which make it suitable to address important environmental issues such as ozone and temperature trends. This study will review some basic aspects of the latest version of the CMAM. Results from multi-year simulations will be presented to investigate the strengths and limitations of the model and to identify various areas of model development, with a particular focus on ozone.

Session 2-B-3

Middle Atmosphere Measurements and Modelling 1 / Mesures et modélisation de l'atmosphère moyenne 1

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Session 2-B-3

Middle Atmosphere Measurements and Modelling 1 / Mesures et modélisation de l'atmosphère moyenne 1

Chair / Président : Kimberly Strong

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2-B-3.5, 6

The Canadian Middle Atmosphere Model (CMAM) Data Assimilation Scheme

Saroja Polavarapu, Shuzhan Ren, Yves Rochon, David Sankey
Data Assimilation and Satellite Meteorology Division, Meteorological Service of Canada

A data assimilation scheme has been developed for the Canadian Middle Atmosphere Model (CMAM), a climate model with fully interactive radiation, chemistry and dynamics extending from the ground to the top of the mesosphere. While data assimilation has been used for operational numerical weather forecasts for three decades, its application to other types of models, and specifically climate models, is more recent. While the goal of assimilation for weather forecast models is to produce an initial state that leads to the best forecast, for climate models there are different motivations. Firstly, analyses can be used as correlative information against which middle atmosphere measurements can be compared. This was the motivation behind the development of the stratospheric version of the UK Met Office model (Swinbank and O'Neill, 1994). Their analyses were widely used both for comparisons against UARS (Upper Atmosphere Research Satellite) measurements and model simulations. Secondly, the process of combining models and observations forces a better understanding of model errors. Since models represent our current knowledge of atmospheric processes, this improved understanding of model error may lead to new insight into middle atmospheric dynamics, chemistry and the interplay between the two.

The CMAM assimilation scheme used is a modified version of the operational 3-dimensional variational assimilation (3DVAR) scheme of the Canadian Meteorological Centre. The CMAM+3DVAR system is unique in the world in coupling data assimilation with a full climate model that includes (1) the mesosphere, and (2) interaction between radiation, chemistry and dynamics.

In this presentation, we will describe some of the challenges involved in developing an assimilation scheme for the mesosphere and with chemistry, such as the development of background error statistics "from scratch", dealing with the impact of tropospheric observations on the mesosphere, and developing a method for estimating ozone model errors without an ozone assimilation.

2-B-4.1

Biological Impact of Eddies in the Gulf of Alaska, based on SeaWiFS and Satellite Altimetry Observations

Peter Brickley [1], William Crawford [2], and Andrew Thomas [1]
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[2] *Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, B. C.*

Analysis of four year of SeaWiFS ocean color data and TOPEX sea surface height anomaly fields suggest that mesoscale eddies play a major role in determining the distribution of surface phytoplankton biomass in many regions of the Gulf of Alaska. A major fraction (>20%) of total chlorophyll variance is associated with mesoscale features straddling the shelf break and extending several hundred kilometers into the central Gulf. Two processes appear to dominate. Eddies along the periphery of the Gulf transport phytoplankton from productive shelf and shelfbreak regions into the more oligotrophic Gulf interior. Phytoplankton biomass within eddy centers is often enhanced in spring and autumn, but may be suppressed at other times, depending on the relative temperature, nutrient concentrations, and proximity to the shelf.

In general, anticyclonic eddies dominate, beginning with their formation in winter along the eastern continental margin of the gulf. In both these young eddies and in second-year eddies in the Gulf interior, the SeaWiFS data show that spring increases in phytoplankton concentration occur earlier within eddies than in surrounding waters. By late spring and summer, when coastal waters support higher plankton biomass, eddies that straddle the continental margin entrain coastal plankton concentrations into their outer rings, advecting them several hundred kilometres into the gulf. In autumn, phytoplankton concentrations are elevated in eddy centers, perhaps due to storm-generated upward mixing of nutrients and/or subsurface plankton into the surface waters observed by SeaWiFS. Winter stirring may also explain locally enhanced chlorophyll observed the following spring in second year eddies far from the shelf. Finally, some eddies enter the Alaskan Stream and drift slowly to the southwest, advecting plankton-rich coastal waters into the deep Gulf interior and oligotrophic interior surface waters onto the continental margin. Each of these mechanisms has implications at higher trophic levels and for carbon flux. In addition, such processes are likely susceptible to interannual variability imposed from external sources.

2-B-4.2

Physical Processes of Haida Eddies of the Eastern Gulf of Alaska: Formation, Transport and Currents

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[2]*Scripps Institution of Oceanography, University of California, San Diego*

A numerical model forced with average annual cycles of climatological winds, surface heat flux, and temperature and salinity along the open boundaries is used to demonstrate that anticyclonic Haida Eddies are generated each winter off Cape St. James, at the southern tip of the Queen Charlotte Islands of western Canada. Annual cycles of sea surface elevation measured at coastal tide gauges and at TOPEX/POSEIDON crossover locations, and currents measured at historical mooring locations are reproduced with reasonable accuracy.

After formation, these eddies drift seaward into the Gulf of Alaska, transporting warmer, fresher waters into deep-sea regions. Central waters of eddies rise 0.1 to 0.4 metres above surrounding waters, and enable their drift through the gulf to be monitored by radar sensors on satellites that measure sea surface height anomaly (SSHA). While within a few hundred kilometres of the continental margin, Haida Eddies entrain and sweep coastal waters westward into the Gulf of Alaska in their outer rings along their southern side. Deep-sea water is transported into the continental margin along the northern side of eddies. However, Lagrangian drifter observations reveal that central regions of these eddies trap surface water in summer, permitting only slow exchange with the surrounding ocean. Detailed drifter observations in one small eddy in summer revealed constant orbital period within 35 km of the

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Biophysical Studies of Ocean Ecosystems / Études biophysiques des écosystèmes marins

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eddy centre. The more frequent storms of winter blow surface waters out of eddies, and likely mix deep nutrients up to the surface.

Eddies may survive for several years in the Gulf of Alaska. Even two and three-year-old eddies impact surface currents. For example, an iron-enriched patch of surface water drifted in a clockwise path around an old eddy in the summer of 2002 during SERIES (Subarctic Ecosystem Response to Iron Enrichment Study) near Ocean Station Papa at 50N, 145W.

2-B-4.3

Estimates Of Secondary Production From NPZ-Type And Copepod Life History Models : Are The Two Approaches Ecologically Coherent?

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[2] *University of New Hampshire, Ocean Process Analysis Laboratory, Durham, NH*

Planktonic ecosystem models known as NPZ type models have been coupled with 3D climatically-driven circulation models for nearly a decade. The role of zooplankton in such models is, however, poorly represented because the Z compartment comprises an ensemble of metazoan species with variable biological characteristics. With growing evidence of marine ecosystem changes in response to climatic variability there is an increasing need for more detailed studies of zooplankton population dynamics. Recent efforts in the North Atlantic GLOBEC community have focused on the development of coupled zooplankton/physical models of *Calanus finmarchicus*. The emerging 3D coupled models of *Calanus* life history are promising tools, but generally are not yet well-coupled to primary production. Dynamic coupling of copepod life history model and NPZ model in a climatically driven 3D physical framework requires a computer power that is not available in the Canadian oceanographic community at this time. Nevertheless, there may be ways to define trophic constraints between model types by comparing secondary production estimates generated by the NPZ and life history models. We present two examples of coupled NPZ-type and *Calanus* life history models developed for the Gulf of St. Lawrence and compare the simulated zooplankton production in order to evaluate the ecological coherence between the two approaches.

2-B-4.4

Quantifying Changes In Zooplankton Community Structure And Secondary Production In The Strait Of Georgia Using An Optical Plankton Counter

Tomas Bird[1], Dr John Dower[1] and Dr Ken Denman[2]
[1]*University of Victoria*
[2]*Canadian Centre for Climate Modelling and Analysis*

The use of Optical Plankton Counters (OPC's) to monitor zooplankton populations has come under fire, in part because of concerns that OPC's and plankton nets do not "see" the zooplankton community in the same way. However, analysis of data from a high-frequency time series using traditional nets and an OPC indicates that, on average, the two methods do tell the same story about how zooplankton populations change through time. Coherent fluctuations in the two series are visible in both biomass and community structure. Likewise, the rate of decay of similarity between sample pairs is the same for net and OPC data. Our next step is to use our OPC data in conjunction with biomass-spectrum theory to construct estimates of zooplankton growth. We will also compare these results to estimates obtained from other techniques for estimating secondary production (e. g., laboratory incubations and a new chitobiase assay). Sampling over the spring bloom in the Strait of Georgia will provide data for all three techniques, the results of which will be discussed.

2-B-4.5

Revisiting the Role of Fresh Water in the Timing of the Spring Bloom in the Strait of Georgia

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The Strait of Georgia is a highly productive, semi-enclosed, marine ecosystem lying between Vancouver Island and mainland British Columbia. The Strait receives large quantities of fresh water from the Fraser River with peak values occurring in late May/early June. Tidal currents within the Strait itself are moderately strong (order 50 cm/s) and the predominantly along-strait winds are less strong than those experienced off the west coast of Vancouver Island.

Yin et al (1997) proposed a model for the timing of the spring bloom in the Strait of Georgia. Stratification for the bloom was provided by the start of the Fraser River freshet and was destroyed by strong winds. If the bloom was sufficiently delayed, it could be greatly suppressed by the grazing pressure from Neocalanus plumchrus.

Recent high frequency sampling, particularly from a BC Ferry, has shown that the 2002 bloom occurred well before the start of the freshet. A review of late 1990's data suggest a similar timing. We will present the evidence for a revision of the model and suggest an updated one.

Session 2-C-1

Weather, Climate and Health 1 / Temps, climat et santé 1

Chair / Président : Denis Bourque

Tuesday 3 June 2003
mardi 3 juin 2003

Room / Salle Panorama

2-C-1.1

Associations Between Meteorological Factors and Emergency Room Visits in a Canadian Children's Hospital

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Objectives: We used the case-crossover study design to examine associations between meteorological variables and reasons for presentation at the emergency room (ER) of a children's hospital in Eastern Ontario, Canada.
Methods: Emergency room data from the Children's Hospital of Eastern Ontario were extracted from 1992 to 2000 for the following variables: age, sex, date and hour of presentation and presenting complaint as coded by the International Classification of Diseases System. Hourly values of meteorological variables were made available by Environment Canada. For modeling purposes, both the emergency room visits and meteorological variables were summarized according to six-hour time intervals.
Results: Twenty-nine percent of the 434,140 ER visits that occurred during the study periods were injuries. During the winter months, using an ambi-directional control period, the occurrence of snow was associated with a 6% (95% CI=3% to 6%) increase in the number of injury-related visits. Similarly, freezing precipitation was associated with a 14% (95% CI=9-18) increase in such visits.
Conclusions: The case-crossover design used in this large data set has demonstrated a significant relationship between meteorological conditions of snow and freezing precipitation in the 6 hours prior to presentation and emergency visits for injuries. Extending these analyses to other locations and disease grouping could provide a useful means to develop predictive models that could be applied to provide valuable information to plan medical staffing levels or to deliver public education messages to reduce morbidity.

2-C-1.2

Ophthalmological Emergency Examinations, Weather and Environmental Conditions; Paris Area, 1997 – 2000. A Multivariate Statistical Analysis

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A statistical multivariate analysis based on a data file of 100 000 cases of daily ophthalmological emergency examinations from the Quinze-Vingts hospital (leading French National Center of Ophthalmology) aimed to compare these clinical data on the one hand to meteorological, pollinic and pollution data on the other hand during a three years period of time (1997/05/01 to 2000/07/30). The clinical statistical description indicated :

- a regular growth of activity throughout the three years (trend);
- a weekly cycle, with a lower activity on Sundays and a higher on Mondays (and Saturdays), including a "weekends and holidays" effect;
- a seasonal cycle, with a maximum summer activity / minimum winter activity;
- a statistical bias during the days around the 11th of August, 1999, the eclipse days (with isolated peaks over 200 cases a day compared to a mean value of 79 cases / day).

A preliminary daily synoptical analysis confirmed in broad outlines the first feelings of our medical team : hot (or warm) days, pollution peaks, windy days or convective situations would correspond to the 18 days with a highest clinical activity. Then the results of a first Multvariate Regression and a

Step Forward Selection were confirmed by a second Multvariate Regression on a "test file" and by a Logistic Regression. All together showed a significant impact of the following predictors :

- Automatic Weather Classification (BENICHOU) at 850 hPa;
- Maximal day temperature (warmest days correspond to a higher examinations rate);
- ATMO global pollution index of the previous day;
- Pollen rates of grasses and oak trees (among ten of the main pollens in the Paris area);
- Humidity and wind also appeared among the best group of 12 predictors.

This collaboration between Météo France, Airparif (pollution over Paris), RNSA (pollen data) and Quinze-Vingts Hospital should lead us now to operational daily automatic biometeorological forecasts of the clinical activity for the next and the following day at the Paris NCO. This private information would be given through the "Weather and Health" pages of the "Meteo. fr" Website.

2-C-1.3

Relationship of Seasonality and Heart Failure in Canada

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[3]*Environment Canada, Toronto*

The specific impact of climate on heart failure outcomes has not been well studied. This report examines the association between outdoor temperature and the seasonal variation in heart failure hospitalization and mortality rates in the general population.

We compared the monthly incidence of heart failure-related hospitalizations and deaths for all 139 health regions in Canada from April 1994 to March 1999, and correlated the risk-adjusted age- and sex-standardized event rates with the monthly mean outdoor temperature within these regions. A distinct winter-spring peak and summer-autumn trough was observed in the seasonal rates of heart failure hospitalizations (214.2±9.3 versus 189.2±13.8 per million population per month; $P<0.0001$ for trend) and deaths (15.8±1.9 versus 13.4±1.2 per million population per month; $P<0.0001$ for trend) across the country. A 10oC decrease in monthly mean temperature was associated with a 5.4% (95% CI, 5.0 to 5.9%; P<0.0001) relative increase in monthly hospitalization and a 6.1% (95% CI, 5.8 to 6.4%; P<0.0001) relative increase in monthly mortality. Temperature had a stronger influence among the older populations on both the increases in risk for hospitalization (6.9% among aged 85+ versus 3.8% among aged 15-64 per 10^{o}C; $P<0.0001$ for interaction) and death (10.4% versus 1.1% per 10oC; P<0.0001 for interaction).

The study suggests that strong associations exist between decrease in outdoor temperature and increases in heart failure hospitalization and mortality rates in the general adult population. The elderly are most susceptible to developing heart failure-related complications as the temperature drops.

2-C-1.4

Are High-Impact Weather Events Associated With Waterborne Disease Outbreaks In Canada?

Kate Thomas [1], Dominique Charron [2], David Waltner-Toews [1], and Abdel Maarouf [3]
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In the wake of recent waterborne outbreaks of E. coli 0157: H7, Campylobacter and Cryptosporidium, Canadians are increasingly concerned about the safety of their water supplies.

While these outbreaks have emerged through complex eco-social interactions, there is accumulating evidence that weather can be an influential factor. One recent U.S. study found that over half of the outbreaks in the latter half of the 20th century were preceded by rainfall greater than the 90th percentile. With global warming, Canada is projected to experience milder winters, longer summers, drier summers in many populated areas, and more events of intense precipitation. Drought, high temperatures, intense precipitation events, and flooding may impact the incidence of waterborne disease outbreaks in Canada.

As part of a larger research program into waterborne disease and climate change in Canada, we are examining the relationship between reported waterborne disease outbreaks and extreme weather events. In this presentation we will review the current state of national and international knowledge on this subject, present some preliminary results from our own work, and discuss on-going investigations and future plans for this research.

2-C-1.5
The Risk of Being Injured while Driving under the Influence-Of Weather
Brian Mills [1] and Jean Andrey [2]
[1] *Adaptation and Impacts Research Group, Meteorological Service of Canada, c/o Faculty of Environmental Studies, University of Waterloo*
[2] *Department of Geography, University of Waterloo,*

Past studies have demonstrated the influence of weather events on motor vehicle collision risk. Precipitation, through reduced road surface friction and restricted visibility, has been shown to increase both the risk of collision and injury, although the magnitude varies due to differences in case study location, driving context, and research methods. The authors will discuss interim results from an update of their first empirical analysis of weather-related collision risks for six mid-sized Canadian cities[1,2]. The original study found that collision risk increased on average by 75 percent during precipitation events while injury risk was elevated by about 45 percent relative to normal, dry conditions. The new research is focused exclusively on injury risk over a long period of record and includes additional cities representative of a broader range of climatic conditions than that considered in the original analysis.

1 Andrey, J., B. Mills, M. Leahy and J. Suggett. In press. Weather as a chronic hazard for road transportation in Canadian cities, *Natural Hazards*.
2 Andrey, J., J. Suggett, B. Mills, and M. Leahy 2001. Weather-related road accident risks in mid-sized Canadian cities. Proceedings of the 12th Canadian Multidisciplinary Road Safety Conference, University of Western Ontario, London, ON, June 10-13, 2001.

2-C-2.1, 2
Simulations of Regional Climate with High-Resolution Global Climate Models
P. B. Duffy, B. Govindasamy, J. Iorio, J. Coquard, K. Taylor
Lawrence Livermore National Laboratory, USA

Lack of spatial resolution is one factor limiting the ability of global climate models to simulate regional-scale climates. We have performed global climate simulations at spatial resolutions as fine as 50 km using several of the NCAR family of atmospheric GCMs. We performed simulations of the present climate and of the effects of increased greenhouse gases. Simulations at T42 truncation (300 km resolution) were performed as a baseline for comparison. On scales of a T42 grid cell and larger (i. e. 300 km) agreement between the model results and observations of 20 meteorological quantities is substantially improved by increasing the model's spatial resolution. The predicted response to increased greenhouse gases at fine resolution is globally very similar to that predicted at coarse resolution, but the predicted regional responses can have strong sensitivity to spatial resolution.

We will show examples of how simulated regional climates (including ability to simulate extreme events as well as time-averaged quantities) depend on model resolution.

2-C-2.3
Resolved Scales And Nonlinear Interactions In Limited-Area Models
René Laprise
Canadian Network for Regional Climate Modelling, Département des Sciences de la Terre et de l'Atmosphère, Université du Québec à Montréal

An approximate procedure for evaluating nonlinear interactions between the various resolved scales in nested limited-area models (LAMs) is described. The formal analysis indicates that resolved scales are limited in LAMs compared to global models of similar resolution. This may imply that nonlinear interactions are treated less accurately in LAMs than in global models. The analysis further reveals that the lateral boundary nesting acts as a type of large-scale closure which is required by LAMs due to their limited computational domain.

2-C-2.4
Validation of the Nesting Technique of a Nested Regional Climate Model (RCM) by the Protocol "Big Brother" during the Summer Season
Milena Dimitrijevic and Rene Laprise
Universite du Quebec a Montreal, Ouranos

The ability of an RCM to reproduce successfully the fine-scale features of regional climate during the summer months with a perfect-prognosis approach nicked-named "Big Brother" Experiment (BBE) is presented. The BBE establishes a reference virtual-reality climate from an RCM large and high-resolution domain: this simulation is called Big-Brother simulation. This reference simulation is then degraded by removing (filtering) short scales that are unresolved in today's global objective analyses and climate models (GCM). The resulting fields are then used as nesting data to drive a RCM (called the Little Brother) which is integrated at the same high-resolution as the Big Brother, but over a sub-area of the Big-Brother domain. The climate statistics of the Little Brother are then compared with those of the Big-Brother simulation over the Little-Brother domain. Differences between the two climates can thus be unambiguously attributed to errors associated with the dynamical downscaling technique, and not to model or observational limitations. In a previous work a 45-km grid version of the Canadian RCM has been applied to two regions of North America (the East and West Coasts where the orographic forcing varies greatly) for four months of February to investigate the ability of RCM to reproduce the fine-scale features during the winter and under the context of complex topography.

The current study employs the same methodology (BBE) but for different meteorological conditions i. e. during the summer months and for West Coast of North America. Results are presented for five

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Climate and Climate Change 5 / Le climat et changement de climat 5

Chair / Président : Daniel Caya

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months of July of 1990 to 1994, for the stationary and transient parts of the fields decomposed by horizontal scales. Three degrees of filtering as well as various update frequencies of the lateral boundary conditions have been employed. These results help to determine the optimal downscaling ability of RCM.

2-C-2.5
Regional Snowpack Modelling Over Canadian Landscapes
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[2]*Department of Atmospheric and Oceanic Sciences, McGill University*

High latitude regional climate modelling is particularly problematic for two basic reasons: a general lack of reliable observed data, and an incomplete understanding of cold climate processes. Nowhere is this more apparent then in the simulation of snow. Snow cover shows the largest spatial and temporal variability of all surface covers in the northern hemisphere, with up to 50% of North America and Eurasia seasonally covered, and it is well known to have an important effect on the global climate. Yet it remains a poorly understood quantity. For example, the snowpack energy budget has considerable uncertainty in every term. Net solar radiation at the snow surface is sensitive to the interplay between fractional snow coverage and albedo - both of which must be parameterized. Upward longwave radiation depends on the emissivity of snow - usually assumed close to 1 in models, but which has been observed as low as 0.8 over cold snow. Turbulent transfer under stable atmospheric conditions is poorly understood in general: over snow covered surfaces the situation can be complicated by many factors including significant increases in surface roughness and sublimation due to blowing snow, local advection and mesoscale circulations associated with patchy snow etc.

All of these examples are further complicated by complex couplings with the overlying atmosphere, and a comprehensive examination of snowpack processes requires a fully coupled atmospheric/land-surface model. Because of the tremendous heterogeneity inherent to the Canadian land surface, a high resolution regional climate model which makes use of a detailed soils and vegetation data set would appear to provide the most suitable tool for snowpack process studies in Canada. In this study a detailed evaluation of the simulated snowpack in the Canadian Regional Climate Model is presented. Three contrasting surface types are examined - prairie, boreal forest, and Arctic tundra - each of which has its own challenges with respect to both modelling and observing. A careful analysis of the simulation based on a variety of remotely sensed and conventional surface data begins to unravel which modelled processes require more attention.

2-C-2.6
Sensitivity of the Canadian Regional Climate Model to Cloud and Land Surface Formulations
Arturo Quintanar [1] , Daniel Caya [2] and René Laprise [1]
[1] *Département des Sciences de la Terre et de l'Atmosphère, Université du Québec à Montréal*
[2] *Ouranos*

Two versions of the Canadian Regional Climate Model (CRCM) developed at UQÀM are used to simulate the period June-July 1993 over the Upper Mississippi River Basin (UMRB). The objective of the study is to examine the ability of these two model versions to capture an intense precipitation episode that led to flooding in the central United States during that time period. The study is a follow up of the Project to Inter-compare Regional Climate Simulations (PIRCS).

While the dynamical core of both CRCM versions is identical, the cloud physical parameterizations and the land-surface schemes are different. In version A of the model, the Kain-Fritsch convective cloud parameterization is used and the land-surface scheme consists of a "beautified" bucket model. Version B includes the modelled physical processes that have been in use with the third-generation of the Canadian General Circulation Model.

The two simulations exhibit significant differences as far as precipitation, evapo-transpiration and horizontal fluxes of moisture are concerned. The origin of these differences can be attributed, in principle, to the different formulations of the physics and the different handling of the water budgets in both the atmosphere and the soil. Nevertheless, these two different physical parameterizations can enhance land-atmosphere feedbacks in such a way that can drive mesoscale circulations in different manner and produce a different hydrological response. The study also emphasizes the differences that both versions show when compared to a number of observed severe events. Version A has an overall tendency to produce excessive accumulated precipitation while version B underestimates this quantity. Both versions are able to capture the general dynamical features associated with these events.

Session 2-C-3

Middle Atmosphere Measurements and Modelling 2 / Mesures et modélisation de l'atmosphère moyenne 2

Chair / Président : Ted Shepherd

Tuesday 3 June 2003
mardi 3 juin 2003

Room / Salle Richelieu

2-C-3.1, 2

Measurements of ClO in the Polar Lower Stratosphere from the UARS and EOS Aura Microwave Limb Sounder Experiments

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The Microwave Limb Sounder (MLS) experiments provide vertical profiles of atmospheric composition, temperature, and pressure by measuring millimeter- and submillimeter-wavelength thermal emission from the limb of Earth's atmosphere. The first MLS experiment in space, launched onboard the Upper Atmosphere Research Satellite (UARS) in September 1991, measured the global distribution of several stratospheric species for nearly a decade; however, because the sampling frequency became increasingly irregular in later years, the majority of the measurements were obtained during the unusually cold conditions of the mid-1990s. In this talk we will focus on UARS MLS measurements of ClO, the predominant form of reactive chlorine involved in stratospheric ozone destruction. Daily maps and equivalent latitude/potential temperature cross sections will be used to show interhemispheric and interannual variations in enhanced ClO abundances, and time series of different slices through the data will be examined to develop a comprehensive picture of the mean evolution of active chlorine in the lower stratospheric winter polar vortices. Climatological ClO fields will be derived by averaging together the results for individual years. At the end of the talk, the greatly enhanced capability of the next-generation MLS instrument, to be launched in early 2004 as part of NASA's Earth Observing System (EOS) Aura mission, will be briefly described.

2-C-3.3, 4

Remote Sensing of the Middle Atmosphere by OSIRIS and SCIAMACHY Measurements of Limb-Scattered Solar Radiation

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The limb-scattering observation technique combines the advantages of conventional observation geometries such as nadir-backscatter and solar occultation: (a) the capability to provide vertical profiles with high vertical resolution (1-3 km) and (b) (near-) global coverage. This allows, for instance to provide a detailed picture of the temporal evolution of the ozone hole's 3D structure. Moreover, trace constituent retrievals from limb-scattering measurements are well suited for comparisons with CTMs and for data assimilation. The Canadian Optical Spectrograph and InfraRed Imaging System (OSIRIS) instrument on the Swedish-led Odin satellite and the SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) on ESA's Envisat are two recently launched hyperspectral sensors performing measurements of limb-scattered radiance spectra in the UV/Vis spectral range. These instruments allow the retrieval of vertical profiles for a variety of minor stratospheric constituents, such as O3, NO2, BrO and OClO, as well as the detection and mapping of optically thin polar stratospheric clouds (PSCs). Furthermore, mesospheric absorption and airglow emission features can be used to retrieve vertical profiles of several mesospheric constituents. This talk provides an overview of the capabilities of the limb-scattering observation technique, and summarizes the species already retrieved on an operational basis, and the species that are in principle retrievable and will be available in the near future.

2-C-3.5

Ground-Based FTIR Atmospheric Absorption Measurements of Nitric Acid in the High Arctic above Eureka, Canada, Throughout the Winter Of 2001/2002

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Total columns of gaseous nitric acid were measured for the first time above the Arctic Stratospheric Ozone Observatory at Eureka (800N, 860W) during the four months of polar night, using a Fourier Transform spectrometer and the moon as light source. The data were obtained as atmospheric absorption spectra recorded with a Bomem DA8 Fourier Transform infrared (FTIR) spectrometer from October 2001 to March 2002. In previous winters atmospheric absorption spectra could be recorded only with the sun as light source. Being confined to only solar absorption measurements precludes the spectroscopic investigation of phenomena that frequently occur during polar night, such as the development of Polar Stratospheric Clouds (PSC's) containing nitric acid aerosol.

By increasing the light sensitivity of the solar tracking system, by approximately five orders of magnitude, it became possible to track the moon also, and thereby record infrared absorption spectra of atmospheric nitric acid. The lunar nitric acid measurements are in good agreement with our corresponding solar measurements made just before and after polar night. The capability of measuring nitric acid for about a week around each full moon opens up the possibility of monitoring the evolution of this gas throughout the arctic winter and hence the opportunity to study its relationship and role with respect to other atmospheric constituents such as aerosols, PSC's, and various gases, as well as atmospheric dynamics. Our nitric acid column amounts show a general increase throughout polar night.

2-C-3.6

Retrieval of Nitric Acid and Ozone Profiles from Low-Resolution Emission Radiometers Flown on Three MANTRA Balloon Missions

M. Toohey [1], B. M. Quine [2], K. Strong [1], D. Wunch [1], C. T. McElroy [3], C. Midwinter [3], J. R. Drummond [1], J. Davies [3], P. Fogal [4], J. Olson [4], C. McLandress [1], T. Shepherd [1], and the MANTRA 2002 Science Team
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Results are presented for two infrared emission radiometers flown on the MANTRA balloon missions. Three MANTRA campaigns have culminated in balloon launches on August 24th 1998, August 29th 2000, and September 3rd 2002, from Vanscoy, Canada (52°N, 107°W). Raw radiance measurements collected during each balloon ascent are analyzed using a forward estimation technique to simultaneously recover multiple trace gas profiles from the low-resolution spectral measurements of atmospheric radiance. The technique uses detailed atmosphere and instrument models and a least-mean-squares simplex estimator to iterate best-fit volume mixing ratios for several gas species, based on atmospheric emission data taken in the 800-1250 cm^{-1} atmospheric window at an instrument resolution of 20 cm^{-1}. Retrieved vertical mixing ratio profiles for ozone and nitric acid are compared with those derived from ozonesondes for each year, as well as with output from the Canadian Middle Atmosphere Model (CMAM), a fully interactive chemistry-climate model. Relevant retrieved profiles are also compared with infrared solar occultation spectra recorded by a high-resolution Fourier transform spectrometer in 1998 and 2002 missions, as well as with available overpass data from the SCIAMACHY and MIPAS instruments onboard the ENVISAT platform.

Session 2-C-3

Middle Atmosphere Measurements and Modelling 2 / Mesures et modélisation de l'atmosphère moyenne 2

Chair / Président : Ted Shepherd

Tuesday 3 June 2003
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Session 2-C-4

Air-Sea Interactions and Waves 1 / Interactions air mer et vagues 1

Chair / Président : Peter Smith

Tuesday 3 June 2003
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Room / Salle Pinnacle

2-C-4.1, 2

Report of an Inter-Departmental Panel on Operational Canadian Coupled Modelling Capacity

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It is now widely recognized that weather and climate prediction models need good representations of interactions with the oceans. Recent improvements in basin and global-scale ocean models and the availability of global oceanographic data have made it reasonable to consider the development of coupled ocean-atmosphere models with assimilation of data into both components - potentially providing more reliable hindcasts, nowcasts and forecasts of ocean and atmosphere states. Of particular relevance, the ARGO float program, to which Canada is a major contributor, is expected to have about 3000 floats deployed in the global oceans by the end of 2003. Together with other data sets (e. g., altimeter, remotely sensed SST, and tropical moored arrays) there is tremendous potential for the development of data assimilative ocean models. With this in mind, on Monday August 26 and Tuesday August 27 2002 a workshop on the theme of "Assessing Operational Global Marine Environmental Prediction for Canada" was held under the auspices of the Centre for Marine Environmental Prediction (CMEP) based in the Department of Oceanography of Dalhousie University. There were presentations outlining related needs within the Meteorological Service of Canada (MSC), the Department of Fisheries and Oceans (DFO), and the Department of National Defence (DND). Experts from other countries that have embarked on similar programs shared their experience and helped assess whether this is feasible and desirable for Canada. Keynote presentations on the international Global Ocean Data Assimilation Experiment (GODAE) and the related ocean observation program set the scientific context. After considering the available Canadian expertise, participants from MSC, DFO, DND and universities held discussions and decided to recommend that Canada move ahead with the development and implementation of an operational global marine environmental data assimilation and prediction program. Participants also discussed the most effective way of proceeding.

As a follow-on to this workshop, an inter-departmental advisory panel (Doug Bancroft (DFO), Hal Ritchie (DOE), Andy Cameron (DND) and Keith Thompson (University)) has been established to make specific recommendations on an operational Canadian coupled modelling capability. The panel is investigating the need, opportunity and feasibility of developing and implementing an operational Canadian atmosphere-ocean-ice modelling system. The panel is formulating recommendations to be considered by DOE, DFO and DND management. This program would be a long-term inter-departmental activity, requiring new A-base resources from the collaborating departments. The panel's findings and recommendations will be presented at the CMOS Congress.

2-C-4.3, 4

High Latitude Air-Sea Interaction: Lessons Learned from the Labrador Sea Deep Ocean Convection Experiment

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The Labrador Sea region in winter is a region of extremes that result in a variety of interesting meteorological and oceanographic phenomena which play a direct role in the dynamics of the global climate system. As one moves from the frozen continent to the marginal ice zone and then to open water, there is a dramatic change in surface temperature, moisture availability and roughness. The region is strongly in influenced by the passage of synoptic-scale cyclones as they transit from Newfoundland to Iceland. Their passage results in sudden and pronounced changes in the air temperature, humidity, wind speed and direction in the region. In the northwesterly flow that is established after the passage of an archetypical cyclone, the advection of cold and dry arctic air over

the warm surface waters of the Labrador Sea results in intense air-sea interaction and a significant transfer of heat and moisture from the ocean to the atmosphere. Evidence for this interaction can be found in the linear, cellular and vortical convective clouds systems observed in satellite imagery to develop in the wake of these cyclones. The north flowing warm and salty West Greenland Current and the south flowing cold and fresh Labrador Current form a cyclonic gyre that, through geostrophic balance, results in a doming up of isopycnals that acts to expose the deep ocean to the atmosphere. The exchange of sensible and latent heat to the atmosphere leads to a deep and weakly stratified oceanic mixed layer that is susceptible to convective overturning. Indeed the Labrador Sea is one of the few locations where deep ocean convection occurs and as such plays an important role in the thermohaline circulation of the world ocean.

The Labrador Sea Deep Ocean Convection Experiment was established with the objective of improving our understanding of the process of deep convection and the role that the atmosphere plays in its forcing. Aircraft and ship-based observations of air-sea interaction in the region were made over a one month period during the winter of 1997. In this talk, I will present an overview of the results of this observational program and its implications for our knowledge of high latitude air-sea interaction and its representation in regional and global models.

2-C-4.5
Energy-Flux Balances in Surface Waves
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[2]*Bedford Institute of Oceanography, Canada*

Many investigators have attempted to examine the role of wave-wave interactions in wind wave generation via either long-term numerical simulations or via estimates of explicit source terms within the complete radiative transfer equation. Results from these investigations are somewhat difficult to interpret due to the large number of degrees of freedom within wind wave spectra. In this paper, we shall treat the energy fluxes within the spectrum as a primary measure of the role of wave-wave interactions, including both direct and inverse energy fluxes. In particular three phenomena will be addressed. First, the amount of energy transferred into very high frequencies (assumed lost to viscosity and wave breaking) is examined in terms of observed spectral shapes and a universal constant for these flux rates will be evaluated. Second, the location of the "null point" is evaluated for these spectra, in terms of some conventional parameters for an f^{-4} spectrum. This location is where no net energy is transferred via wave-wave interactions (i. e. a point where the direct and inverse fluxes are equal). And third, the relation between this null point and net energy fluxes onto the forward face of the spectrum is given.

The energy-flux balance derived above, based on the theoretical and observational framework presented there, are used to help interpret wind-wave generation and air-sea momentum exchanges. Within this interpretation it is shown that the net momentum entering the wave spectrum is approximately constant over a wide range of wave age. When a fully-developed stage of growth is approached, the spectral shape adjusts and the amount of energy transferred to the forward face through wave-wave interactions greatly diminishes. In this context, a strong wave-breaking source term (or some other strong energy sink term) on the forward face of the spectrum is no longer required to achieve an energy balance in this stage of wave development.

These findings have very significant consequences on 1) the formulation of third-generation wave models, and 2) the physics of air-sea interactions. In particular, it is shown that 1) the documented tendency of third-generation wave models to underestimate wave heights under certain conditions may be due to an overestimation of wave breaking within these models and 2) important aspects of fetch-limited and duration-limited wave growth characteristics are interrelated through the degree of importance of this breaking source term on the net energy balance within the spectrum.

Session 2-C-5

Impacts of Weather (land and ocean) and Climate on Society 2 / Les impacts du temps (terre et mer) et du climat sur la société 2

Chair / President : Tanuja Kulkarni

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2-C-5.1, 2
Lake-Ice Thickness, Active-Layer Depth, and Climate Variability, Richards Island, Western Arctic Coast, Canada
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Department of Geography and Environmental Studies, Carleton University, Ottawa

The potential impact of climate change on permafrost terrain is commonly described in terms of catastrophic effects, such as landslides, due to melting of near-surface ground ice, or warming of ground temperatures. Near the western Arctic coast, much of the transportation infrastructure depends on river navigation in summer and the construction of ice roads in winter. This paper considers two aspects of the region that are closely associated with climatic conditions and describes how variation in air temperature during the past twenty years has influenced their development. First, April lake-ice thickness has been monitored since 1992 at a site on Richards Island. The thickness of the ice cover has varied up to 50% due to changes in snow depth. The snow depth appears to be a primary control on the ice thickness and the freezing index for the winter is the secondary influence. In contrast, for an active-layer course monitored since 1983, the thawing index for the summer is the primary controlling variable on thaw depth, but the snow depth in the previous winter is also associated with the extent of thawing. These data illustrate the critical influence of snow conditions on terrain freezing and thawing. The accumulation of snow in winter, however, is subject to many factors that may appear random in aggregate, such as redistribution by the wind, making prediction difficult.

2-C-5.3
Socio-economic Implications of a Changing Climate in the Great Lakes – St. Lawrence Region
Linda Mortsch
Meteorological Service of Canada

The socio-economic vulnerability of the Great Lakes - St. Lawrence region to a changing climate is explored by highlighting three plausible, future effects. First, an increase in the intensity of precipitation is used to describe the ramifications for infrastructure design, cost and performance as well as associated influences on flooding and safety and water quality and recreation. Then, a reduction in seasonal streamflow is linked to implications for watershed management and water quality targets. Lastly, lower water levels in the Great Lakes are used to discuss consequences for water apportionment, hydropower generation, commercial navigation, and recreation. Many of the impacts will require adaptation and necessitate investment in research, proactive planning and management, and institutional change.

2-C-5.4
Asseessing Climate Change in an Integrated Watershed Management Framework
James M. Byrne
University of Lethbridge

Integrated Watershed Management (IWM) considers natural supply and demands; and natural and human induced changes to supply/demand functions. Geomatics tools linked to hydrologic models are utilized to record/address/model physical, chemical and biological watershed processes; and to predict human influence on these processes. Watershed scale data layers are constructed and maintained for any/all variables that may impact watershed ecosystems and/or human interactions and applications in watershed resource management. Terrestrial and aquatic ecosystem processes, including the roles of human altered systems (e. g. agricultural, industrial and urban land use) are combined to allow scientists and managers to estimate impacts of one or many variables on local and watershed scale processes.

Meteorological variables influence (and often control) most ecological variables and processes in the watershed. Simple algorithms estimating impacts of climate change on individual variables do not reflect the cumulative or cascading interactions in watershed processes. Regional climate models do

not have the resolution to adequately deal with these processes. High resolution IWM models provide a means of accurately reflecting how watershed processes will respond to changing climates.

2-C-5.5

Projecting Climate Change-Induced Impacts on Future Canadian Fire Regimes

Brian Stocks, M.D. Flannigan, B.M. Wotton, B.D. Amiro, J.B. Todd, K.A. Logan, E.M. Bosch, D.L. Martell, and W.R. Skinner

Forest fire is the major and most visible disturbance regime in Canadian forests, burning over an average of ~3 million hectares annually, threatening human life, destroying property, and significantly affecting Canada's economically vital wood supply. Direct fire management costs total ~$500 million annually, with larger indirect costs. Forest fires have also been shown recently to exert a major impact on the sink/source strength of Canadian forests, a subject of ongoing international negotiations on atmospheric emissions and the global carbon budget. Current climate change projections suggest a strong increase in the frequency and severity of weather conditions conducive to forest fires across much of Canada, and there is a strong and urgent need to project the extent and impact of future Canadian fire regimes in order to devise and implement effective adaptation strategies. Climate Change Action Fund (CCAF) support has been used in recent years to address these needs.

A database of all large (>200 hectare) fires in Canada was developed using fire report data from all Canadian fire management agencies over the past 4 decades (1959-1999). This spatially-explicit large fire database (LFDB) permitted the first national-scale assessment of forest fire impacts across Canada. Concurrently, national daily weather and fire danger databases were developed for the same time period, and used along with the LFDB, to develop scientifically-sound relationships between fire activity and climate in Canada over the past 50 years. The movement and position of air masses in the upper atmosphere was quantitatively determined to be a major driver of large fire activity through this project. In addition, the amount of carbon released annually through forest fires over the past 4 decades was determined, using the LFDB in combination with outputs from the Canadian Forest Fire Behavior Prediction System.

Scenarios of future forest fire danger have been developed for western Canada, using the high-resolution Canadian Regional Climate Model, and these scenarios, in combination with the LFDB have been used to designate Canadian forest ecozones most vulnerable to increased fire activity with climate change. Preliminary adaptation strategies have been developed at local (community protection), landscape (forest fuel management options), and provincial (level of protection analyses), based on future scenarios of fire danger across Canada, and adaptation research is continuing.

2-C-5.6

Le sahel; l'agriculture, les ressources en eau, le pastoralisme et l'environnement intégré face à la variabilité du climat et à ses changements

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Sciences atmosphériques et enjeux environnementaux, Service météorologique du Canada

Le but de cette conférence est de présenter le contexte et l'avancement d'un projet de coopération entre le Canada (ACDI- Env. Can.) et les pays du Sahel (CILSS - Agrhymet) en ce qui a trait aux impacts du climat; sa variabilité et ses changements ainsi que les stratégies d'adaptations considérées en regard aux ressources en eau, le pastoralisme et l'environnement intégré.

Une revue du contexte climatique (variabilité et changements dans la zone de pluie) et un survol des scénarios climatiques développés pour ce siècle seront suivis d'une présentation des projets d'adaptations envisagés dans ce contexte.

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Impacts of Weather (land and ocean) and Climate on Society 2 / Les impacts du temps (terre et mer) et du climat sur la société 2

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Session 2-D-1

Weather, Climate and Health 2 / Temps, climat et santé 2

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2-D-1.1

New Guideline on Frostbite Development and the Effect of Wind Chill

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Cold wind increases the likelihood of developing freezing injuries on exposed skin, particularly in the face. This observation was reported by several Arctic and Antarctic explorers and by many researchers over the years. Despite this, very few studies have systematically described the effect of the wind chill on the development of frostbite in the face. More studies have described the effect of the wind chill on the development of frostbite in the fingers. The objective of the present study was to describe the effect of cold winds on skin temperatures and heat losses from 5 different parts of the face (chin, nose, right cheek, left cheekbone, forehead), and the time required to develop frostbite during exposure to cold. Twelve subjects (6 males and 6 females) were exposed to sixteen 45 min tests where the wind intensity varied between 0, 16 and 32 km/h. The tests were conducted at 0, -10, -20, -30, -40 and -50°C (only 0 km/h wind was present at -50°C). During the tests, the subjects were dressed for thermal comfort, and rested seated while facing the wind with their bare face fully exposed to the cold wind. Each test was terminated when the elapsed time reached 45 min, the skin temperature reached -2°C or when frostnip developed. During the tests, thermal comfort rating and pain rating on the face was recorded every 15 min. The results show that no frostnip was observed at 0°C and -10°C for any wind intensity. The frequency of frostnip development increases inversely with temperature, while the time to develop frostnip increases with temperature. At -20°C, 17 and 58% of the subjects developed frostnip for the 16 and 32 km/h wind conditions, while at -30 and -40°C, all the subjects developed frostnip at those conditions. For the no wind conditions, 0, 11, 22, and 60% of the subjects developed frostnip for the -20, -30, -40 and -50°C conditions, respectively. The time to develop frostnip decreased from 20 min at -20°C for the 16 and 32 km/h wind conditions to 14, 4, 2.5 and 1.5 min for the -30°C and 16 km/h, -30°C and 32 km/h, -40°C and 16 km/h, and -40°C and 32 km/h conditions. From the 52 cases of frostnip observed, 73% (38 cases) were observed on the nose, while 15, 8 and 4% were observed on the chin, cheek, and forehead, respectively. It was concluded from these results that the times to develop frostbite estimated from the Sipple-Passel Wind Chill Index are too short and need to be revised. A new guideline based on the new Wind Chill Index is being proposed to protect the general population against the development of freezing injuries, particularly in the face.

2-D-1.2

Winter Mortality, Climate, and Climate Change in U. S. Cities

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Some climate and health impact studies have suggested that climate change resulting from increasing greenhouse gas concentrations will have an adverse impact on human mortality in major U. S. metropolitan areas. Most of the focus has been on summer mortality possibly rising from increasing heat and humidity during heat waves and isolated hot days. However, most of the observed warming is concentrated in the winter months, when mortality rates are significantly higher. Further complicating this analysis is the presence of influenza and co-morbid conditions. Influenza is not linked in any straightforward manner to weather and climate, and flu outbreaks exhibit substantial inter-annual variability. Before examining the differential impact of climate warming between winter and summer, the influenza "signal" must be removed. Our goal is to investigate historic changes in winter climate and winter mortality in major U. S. cities in an effort to better understand historic seasonal climate-mortality relationships and possible future changes.

Daily weather and mortality data were extracted from National Weather Service and National Center for Health Statistics archives, respectively, from 1964-1998 for 28 major metropolitan areas. Daily mortality data were age-standardized and organized according to 17 major disease categories. Using

factor analytic techniques, the interplay between these 17 diseases allowed for the identification and removal of an influenza "signal" in the winter monthly time series. Decadal changes in mean monthly mortality are compared between the 1960s-70s, 1980s, and 1990s using a simple model that accounts for base population and monthly temperature changes.

After removal of the influenza signal, our model provides reasonable estimates of mortality in all months. In many northern and interior cities, summer mortality rates are lower than expected owing to various "adaptation" effects. Preliminary results for winter suggest that winter mortality rates are higher than expected even after "removal" of an influenza signal. Over four decades, however, there has been a general tendency for the seasonal mortality amplitude to decline across cities.

2-D-1.3
Climate Change, Health, and Women
Kirsty Duncan
Adjunct Professor, University of Toronto

Climate change will disturb the Earth's physical systems (e. g. weather patterns) and ecosystems (e. g. disease vector habitats); these disturbances, in turn, will pose direct and indirect risks to human health. Direct risks involve climatic factors that impinge directly on human biology. Indirect risks do not entail direct causal connections between climatic factors and human biology.

The Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change elucidates the potential human health impacts of global climate change at both a population and regional level.

The impacts on child health, adult health, and the health of the elderly, however, remain largely unexplored. A paucity of research regarding women's health is also extant, despite increasing interest in the issue.

According to the TAR, climate change is projected to affect such key issues as air quality, food yields and nutrition, water-related infectious diseases, and water supply. Exposure to cooking fuels, access to food, distribution of food within the family, and choice of water sources is often determined by gender. Thus, women's contributions may, in some cases, make them more vulnerable than their male counterparts to climate change. Moreover, it is anticipated that health care will significantly help people adapt to climate change. Unfortunately, not everyone has adequate health care. In some countries, fewer than 25 percent of women visit health-care professionals.

In light of the foregoing, this paper addresses the interrelated and neglected areas of climate change, human health, and women.

2-D-1.4
Climatology and Long-Term Changes in Ultraviolet Radiation over Canada
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Meteorological Service of Canada

Long-term changes in UV-B have been analyzed from 12 years of measurements of spectral irradiance by Brewer spectrophotometers at the Canadian network. The time interval of spectral UV measurements was found too short for reliable detection of long-term changes in UV. To estimate the UV irradiance (at individual wavelengths and spectrally integrated) over a longer time interval, a statistical model has been developed to derive UV-B from global solar radiation, total ozone, dew point temperature, and snow cover. The model was based on 6 years of simultaneous measurements in Toronto and has been tested on data from 6 other Canadian stations. The model demonstrated good agreement with the measurements. For example, the standard deviations of the difference between monthly values of measured and derived erythemaly weighted UV is 3.3% for summer months. The major source of error in the model is likely linked to rare occurrences of absorbing aerosols in the

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atmosphere. Long records of reliable measurements of total ozone, global solar radiation and other parameters made it possible to derive UV-B values at three Canadian stations from the mid-1960s. Trends in derived erythemaly weighted UV at two stations (Toronto and Edmonton) are similar to those expected from total ozone trends. However, the increase in annual UV at Churchill in 1979-1997 is more than twice, what would be expected from the ozone decline. This is found to be due to long-term fluctuations in snow cover and clouds. The statistical model was also used to estimate hourly UV Index values at 45 sites in Canada, where pyranometer data were available. Maps of different statistics of UV radiation such as monthly mean daily erythemal UV irradiation, mean noon UV Index values, 95-percentile of the noon UV index, hourly mean UV Index values were then produced.

2-D-1.5

Impacts of Summer Weather and Air Pollution on Human Mortality in South Central Canada

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Many diseases, especially those of respiratory and cardiovascular systems, most frequently occur during or after a period with specific weather conditions and/or high air pollution concentrations. This study has developed an automated synoptic climatological classification approach to determine the impacts of summer weather and air pollution on human mortality for 4 specific sites in South Central Canada. Surface and upper-air meteorological, air pollution and mortality data for the summer months (Apr.-Sep.) were used in the study. Six-hourly surface observations of air temperature, dew point temperature, sea-level air pressure, total cloud cover, wind speed and direction were retrieved from Environment Canada's Digital Archive of Canadian Climatological Data for the period 1953-2000. Three atmospheric levels of 6-hourly NCEP-NCAR upper-air reanalysis weather variables (air and dew point temperatures, wind speed and direction) were used for the period1958-2000. Air pollution data, including O_3, SO_2, NO_2, CO and COH, was retrieved from the National Air Pollution Surveillance (NAPS) network for the period 1974-2000. Mortality data from Statistics Canada included the daily total non-traumatic mortality (e. g., ICD-9: 001-799) for the period 1950-1998.

An automated synoptic climatological classification approach has been developed using two statistical methods: principal components analysis (PCA) and a clustering procedure. The PCA was performed to reduce a large number of intercorrelated weather variables to a small number of uncorrelated component variables, which can explain much of the variance within the original dataset. The average linkage clustering procedure was used to automatically classify distinctive synoptic types based on the differentiations and similarities of meteorological characteristics between and within weather types. The statistical procedures were able to identify weather types most highly associated with mortality rates and air pollution concentrations. Within-type stepwise logistic regression was performed to analytically determine the meteorological variables and air pollutants that can be used as predictors for likelihood of excess mortality due to weather and/or air pollution.

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2-D-2.1

The Preliminary Results From A 5-Year Simulation Using Canadian Regional Climate Model Over Pan-Canadian Area

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Numerical experiments driven by analyses of observations are used to limit systematic biases due to the driving data used at lateral boundary conditions. To validate the model performance of the new developed version of Canadian Regional Climate Model (CRCM), in this study, a 5-year simulation, which driven by NCEP/NCAR re-analysis data, was performed for the 1987-1991 period. The model domain covers the Pan-Canadian area with 193x145 polar stereographic grid points at a 45km resolution and 29 Gal-Chen levels in the vertical. A high resolution topography data from U. S. navy and the observed monthly mean sea surface temperature (SST) and sea ice concentration (SIC) from the Atmospheric Model Intercomparison Project (AMIP) II were used to reduce external forcing errors. To prevent CRCM large-scale inconsistency from its driving fields in the long-term simulation, a new spectral nudging technique was first introduced in this new version model.

The monthly and seasonal mean results from last four years' simulations were compared with different observation and re-analysis data including Climate Research Unit (CRU) data (precipitation, surface temperature, daily maximum and minimum temperature), Xie-Arkin data (precipitation) and NCEP/NCAR data (surface fluxes and large-scale circulation). The preliminary analysis shown that the CRCM successfully reproduces the basic characteristics and seasonal variability of large-scale circulation over Pan-Canadian area. The annual mean surface temperature simulated by CRCM is 2-4ºC colder than CRU observation over northern Canada and western US, but 2-4ºC warmer over southern Canada and central US. The ocean precipitation simulated by CRCM is consistent very well with Xie-Arkin data, the land precipitation produced by CRCM also agrees well with observations in winter seasons, however, the CRCM overestimates the land summer precipitation over Pan-Canadian area, especially over the western mountain area.

2-D-2.2

Internal Variability in RCM Simulations over an Annual Cycle

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Three one-year simulations generated with the Canadian RCM (CRCM) are compared to study internal variability in nested regional climate models and to evaluate the control exerted by the lateral boundaries information supplied by the nesting procedure. All simulations are generated over large domains and over an annual cycle. The simulations use different combinations of surface and atmospheric initial conditions but all of them share the same set of time-dependent lateral boundary condition taken from a simulation of the Canadian GCM. A first simulation is used as control, the second simulation is launched with different atmospheric and surface IC and finally the third simulation is launched taking its surface IC from the control simulation. Comparison of the root-mean-square differences (RMSD) between each pair of simulations shows distinct seasonal behaviour in the time series of the RMSD. In winter all simulations are almost identical to each other resulting in very low RMSD values while in summer large discrepancies develop between simulations. For water vapour related fields such as precipitation or specific humidity, these discrepancies are sometimes as large as the monthly-averaged variability. Analysis of the climate statistics however shows that, even though the evolution of the various simulations is different in summer, their climates are similar.

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2-D-2.3
Regional Climate Simulations in the Ouranos Consortium
Daniel Caya, with the Simulations' team
Consortium Ouranos, Montréal

The Ouranos Consortium was founded in 2002 at the initiative of the Québec government and by the participation of Hydro-Québec, Meteorological Service of Canada, Université du Québec à Montréal, Université Laval, Institut national de la recherche scientifique du Québec and McGill University. The mandate of the Consortium is to provide its partners with the best information on climate change and adaptation at the regional scale. Part of this mandate is the generation of regional climate change projections. The production of regional climate change projections as well as an active contribution in the development and optimisation of the Canadian RCM is under the responsibilities of project "Simulations" at Ouranos; one of the 14 projects that are making Ouranos. In order to achieve the simulation's part of the Ouranos mandate, a team has been built with peoples from Ouranos and from the Meteorological Service of Canada. This paper will present the schedule of activity of this team with the list of current and perturbed climate simulations that are currently being integrated.

A main set of three simulations is currently in production: A current climate simulation with the Canadian RCM (CRCM) driven by reanalysis from the National Center for Environmental Predictions (NCEP) for the period 1973 to 1999; A current climate simulation with the CRCM driven by outputs from the Canadian Coupled (Atmosphere-Ocean) General Circulation Model (CGCM2) for the period 1968 to 1994 of observed transient Greenhouse Gas (GHG) concentration; and A perturbed climate simulation with the CRCM driven by outputs from CGCM2 for the period 2037 to 2063 of a version of the IPCC is92 scenario of GHG concentration. All these simulations are performed with version 3.6.1 of the CRCM over a very large domain that covers most of North America with large portions of the Arctic, Pacific and Atlantic oceans. Preliminary results from these simulations will be presented.

2-D-2.4
Suitability of the Large Scale Routing Schemes for Use with Regional Climate Models
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2 Ouranos

In the climate modeling community, there is a need for models that can route runoff generated by the land surface component of Global Circulation Models (GCMs) and Regional Climate Models (RCMs) to the ocean cells as it has an important contribution to the buoyancy fluxes in the coastal regions. Routing models are also required to fully evaluate the impact of climate change on water resources. Many approaches for routing water through large-scale systems can be found in literature. One such approach is the cell-to-cell routing. The suitability of such a cell-to-cell routing scheme for use with RCMs is explored.

A simple variable-lag scheme based on Askew's formula for computing the time evolving channel-lags is implemented. The scheme is very similar to that of Arora and Boer (1999, J. Geophys. Res.), but has the advantage that it doesn't require basin characteristics other than basin area and soil type. RCMs have spatial resolutions much finer than GCMs and hence routing needs to be done at a finer scale. The scaling issue associated with routing at different spatial resolutions is addressed in this paper with a comparison of routing results from 1^{o} and 5 min resolutions, with different routing intervals (one day and smaller than one day). The choice of the routing interval is very important and varies with spatial resolution as in any hydrological model. For any given basin, at fine spatial resolution, the routing interval will depend on the basin area and the stream-flow values.

Refining the spatial resolution appears to be insufficient to provide accurate results with the routing models. This study demonstrates that the large-scale routing schemes developed for use in GCMs need to be customized if they are to be used for simulating stream-flows for small selected regions.

For example, when applied directly to northern catchments, which are more subject to icy conditions, the large-scale routing schemes will not produce correct stream-flow values. Processes such as permafrost and freezing of rivers and lakes are important for these basins and must be considered, and associated processes such as groundwater contribution must be adjusted accordingly.

2-D-2.5
The coupling of Canadian Regional Climate Model (MRCC) with Hudson Bay Regional Ocean Model (ROM)
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[2] *Ouranos Consortium on Regional Climate and Adaptation*
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The Canadian Regional Climate Model (MRCC) is being coupled with the Hudson Bay Regional Ocean Model (ROM) in order to develop a fully integrated simulation tool for the study of the regional climate of Eastern Canada. The coupling is achieved with Fortran Pipe technique so that both MRCC and ROM can run simultaneously with communications to exchange data. They will be physically coupled through the use of commonly computed fluxes of water, momentum and energy. As it is still a preliminary work, the authors show only the comparison between the coupled simulation results and the non-coupled simulation ones. The surface sensible flux, latent flux, SST and the sea surface current are the main values to be compared with a limited set of climatic data since these are the most important values in the air-sea interaction processes.

2-D-2.6
A Coupled Regional Climate Simulator for the Gulf of St. Lawrence, Canada
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The climate of Eastern Canada is characterized by atmosphere-ocean-ice interactions due to the closeness of the North Atlantic Ocean and the Labrador Sea. Also, there are three relatively large inner basins: the Gulf of St-Lawrence, the Hudson Bay / Hudson Strait / Foxe Basin system and the Great Lakes, influencing the evolution of weather systems and therefore the regional climate. These basins are characterized by irregular coastlines and variables sea-ice in winter, so that the interactions between the atmosphere and the ocean are more complex. There are coupled general circulation models (GCMs) that are available to study the climate of Eastern Canada, but their resolution (near 350km) is to low to resolve the details of the regional climate of this area and to provide valuable information for climate impact studies.

The goal of this work is to develop a coupled regional climate simulator for Eastern Canada to study the climate and its variability, necessary to assess the future climate in a double CO2 situation. An off-line coupling strategy through the interacting fields is used to link the Canadian Regional Climate Model, developed at the "Université du Québec à Montréal" (CRCM, Caya and Laprise 1999), to the Gulf of St. Lawrence ocean model developed at the "Institut Maurice-Lamontagne" (GOM, Saucier et al. 2002). This strategy involves running both simulators separately and alternatively, using variables from the other simulator to supply the needed forcing fields every day. We present the results of a first series of seasonal simulations performed with this system to show the ability of our climate simulator to reproduce the known characteristics of the regional circulation such as mesoscale oceanic features, fronts and sea-ice. The simulations were done for the period from December 1st, 1989 to March 31st, 1990. The results are compared with those of previous uncoupled runs (Faucher et al. 2003) and with observations.

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2-D-2.7

Simulation of Extra-Tropical Storms: Coupling CRCM to a Dynamical Ocean Model

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In this study, the CRCM (Canadian Regional Climate model) is coupled to POM (Princeton Ocean Model) and the composite coupled model is employed to simulate extra-tropical storms over the NW Atlantic, including Atlantic Canada waters. Five extra-tropical storms are studied: Bonnie (1998), Danielle (1998), Earl (1998), Michael (2000) and the "Superbomb" from January 2000. Results suggest that our coupled model has ability to simulate the storm track and the storm intensity tendency. For Bonnie and Danielle, the thickness at mid-latitudes is flat, baroclinicity is weak, and the storms didn't show strong intensification. On the other hand, the situation for Earl, Danielle and Superbomb is that there was a strong baroclinic environment at mid-latitudes, which is the domain where these storms experienced much of their development. The storms obtained energy from the baroclinic system and developed explosively. These results are consistent with operational experience. Our results also suggest that, initialization or bogussing is very important for the storms with small spatial scale such as Bonnie, Danielle and Michael. But for Earl and Superbomb, the spatial scale is large, and bogussing is not so necessary as with the other three storms.

The ocean feedback has some limited impacts on the storm intensity. These impacts depends on a number of factors, such as propagation speed of the storm, mixed layer depth, thermal stratification below the mixed layer, horizontal extent of the storm and latitudinal domain of the storm, or sea surface temperature (SST). However, during the storm period, the ocean surface shows very significant response to the storms. Storm-induced surface currents, determined by surface wind stress, can be quite large, of the similar magnitude as the Gulf Stream, if the storm has sufficient intensity. *On one hand*, marine storms occurring during the autumn may encounter a mixed layer that is thin. Thus, storm-induced currents may result in a cold wake, with SSTs depressed ~3-5^{o} C to the right of the storm track. *On the other hand*, if winter storms occur when the mixed layer is quite deep, the impacts on SSTs and the upper ocean temperature profile are relatively very minor although storm-induced surface currents are still quite strong.

2-D-2.8

Hailstorm Modeling using a Downscaling Technique

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Global warming of about 0.6°C has been observed during the last century with a marked increase of the mean temperature of the lower atmosphere during the last 10 years. If anthropogenic emissions would not be reduced, current global climate models (GCM) predict a global warming of about 2°C between 1990 and 2100. Such warming may increase the frequency and the intensity of extreme climatic events (i. e., windstorms, heavy rain, tornadoes, thunderstorm days, and hail). The increase of severe weather events may have important impacts on societies, such as loss of life and property damage. However, due to the limited resolutions of GCMs that resolve only large and synoptic atmospheric features, they cannot predict how. To compensate for the limited resolutions of the GCMs, regional climate models (RCM) have been developed during the last decade for downscaling GCM simulations at regional scales. Such technique may be used to simulate severe local weather events, such as tornadoes, thunderstorm and hailstorm events. The purpose of this study is to assess the ability of the Canadian regional climate model (CRCM-2) to help predicting hailstorm events. The CRCM-2, which is a limited-area grid-point non-hydrostatic model that uses a three-time-level semi-Lagrangian semi-implicit time marching scheme, has been applied to the simulation of a hailstorm event observed in Switzerland in 1993. Sensitivity experiments of the model's results to the nested domain and to two moist convection schemes are also presented.

2-D-3.1, 2
Off-line 3D Chemical Transport Modelling of the Stratosphere: Multi-Decadel Simulations of Ozone Variability and Trends
Martyn Chipperfield
School of the Environment, University of Leeds, U. K.

The study of the observed decrease in stratospheric ozone at mid-latitudes is one of the major issues which has driven recent stratospheric research. These decreases, and their seasonality and interhemispheric differences have not been quantitatively explained, though many possible contributing processes have been identified.

In the past 2D (latitude-height) models have been used to study the effect of increases in stratospheric halogen loading on mid-latitude ozone, and these studies indicate that the halogen increase is a likely explanation. However, some 3D dynamical studies have shown that dynamical variability will strongly affect mid-latitude ozone, and a trend in dynamics may even be responsible for part, or all, of the observed trend. A problem with reconciling these somewhat conflicting explanations is that a coupled study containing all of the relevant dynamical and chemical processes has not yet been performed.

Following recent developments in 3D atmospheric modelling, it is now possible to perform long 'full chemistry' simulations at moderate resolution. I will described recent experiments with the SLIMCAT/TOMCAT 3D CTMs forced by ECMWF ERA40 analyses. A number of simulations have been performed which address the role of chemistry and aerosol variations in driving stratospheric O3 changes at mid (and high) latitudes.

2-D-3.3
Observational Analysis of the Containment of Antarctic Vortex Air Following the Split Ozone Hole Of 2002
J. V. Lukovich [1], I. McDade [1], T. G. Shepherd [2], C. S. Haley [1]
[1] *Centre for Research in Earth and Space Science, York University*
[2] *Department of Physics, University of Toronto*

Previous studies have shown that the wintertime Antarctic stratospheric polar vortex may be characterized as an isolated "containment vessel", which is an important requirement for the development of the ozone hole. In September 2002 this behaviour was severely disrupted, as the vortex (and ozone hole) split in two in conjunction with an unprecedented stratospheric sudden warming. It is important to assess for how long the vortex remnants retained their containment characteristics, as this affects the rate at which ozone-hole air mixed with mid-latitude air. In order to address this issue, measurements of various chemical species from the OSIRIS instrument are used and compared with potential-vorticity (PV) fields from meteorological analyses. In particular, it is expected that a distinct correlation would have been established between N_2O and O_3 within the vortex by the time of the vortex split, which would allow such air to be distinguished from mid-latitude air (which has no such distinct N_2O:O_3 correlation) following the split. The vortex edge defined chemically by such correlations will be compared with that defined dynamically by PV.

2-D-3.4
Total Ozone Variations Over Midlatitudes And On The Global Scale
Vitali E. Fioletov and Theodore G. Shepherd
Atmospheric Physics Group, University of Toronto

Several data sets based on satellite (TOMS, SBUV-SBUV/2, GOME) and ground-based measurements are presently available for estimation of latitudinal and global total ozone temporal variations and trends. Systematic differences of up to 3% were found between different data sets. However, when these systematic differences were removed, the residuals agreed to within ±0.5%. While global ozone was fairly constant during the 1990s, the average values of the 1990s are about 2-

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3% lower than those of the late 1970s. About 38% of the global ozone is located between 25°S and 25°N where the data show no decline.

The strongest decline occurs over the 35°N-60°N zone during the winter-spring season; the decline in autumn is much smaller there. Temporal autocorrelations of monthly mean total ozone anomalies over the 35-60°S and 35-60°N latitude bands reveal that anomalies established in the wintertime midlatitude ozone buildup persist (with photochemical decay) until the end of the following autumn, and then are rapidly erased once the next winter's buildup begins. In the northern hemisphere, extending the springtime ozone trend to other months through regression based on the seasonal persistence of anomalies captures the seasonality of the ozone trends remarkably well, suggesting that the trends in all seasons result from whatever mechanisms are responsible for the springtime trends. Over the 35°S-60°S zone, the ozone decline shows less seasonal dependence, and the springtime trend there only accounts for part of the summertime trends. There is a strong correlation between the ozone anomalies in northern hemisphere spring and those in the subsequent southern hemisphere spring, but not the converse, suggesting some kind of interhemispheric dynamical coupling.

2-D-3.5
Correlations of Long-Lived Chemical Species in a Middle Atmosphere General Circulation Model
D. Sankey and T. G. Shepherd
Department of Physics, University of Toronto

Correlations between various chemical species simulated by the Canadian Middle Atmosphere Model, a general circulation model with fully interactive chemistry, are considered in order to investigate the general conditions under which compact correlations can be expected to form. At the same time, the analysis serves to validate the model. The results are compared to previous work on this subject, both from theoretical studies and from atmospheric measurements made from space and from aircraft. The results highlight the importance of having a dataset with good spatial coverage when working with correlations, and provide a background against which the compactness of correlations obtained from atmospheric measurements can be confirmed. It is shown that for long-lived species, distinct correlations are found in the model in the tropics, the extratropics and the Antarctic winter vortex. Under these conditions sparse sampling such as arises from occultation instruments is nevertheless suitable to define a chemical correlation within each region even from a single day of measurements, provided a sufficient range of mixing ratio values is sampled. In practise, this means a large vertical extent, though the requirements are less stringent at more poleward latitudes.

2-D-3.6
Comparison between Chemical Species Measured in the High Arctic during Spring 1999 and 2000 and the Canadian Middle Atmosphere Model
E. Farahani[1], D. Sankey[1], K. Strong[1], T. G. Shepherd[1], R. L. Mittermeier[2], H. Fast[2]
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In the Arctic, springtime ozone columns have suffered unusually high rates of depletion during the 1990s. It is known that long-lived chemical species can supply ozone-depleting radicals under winter/spring condition at high latitudes. Thus observations of these species are crucial in advancing our understanding of stratospheric polar processes causing Arctic ozone depletion. In order to investigate the role of these long-lived chemical species, particularly the nitrogen family which plays an important role in ozone chemistry, we have deployed a UV-visible zenith-sky-viewing grating spectrometer at Environment Canada's Arctic Stratospheric Ozone Observatory (ASTRO), located at Eureka, NU (80.1°N, 86.4°W). The facility accommodates a number of other instruments, including a Fourier Transform infrared (FTIR) spectrometer that is used to retrieve a wide range of stratospheric constituents from solar absorption spectra.

To date, the UV-visible spectrometer has been deployed on five field campaigns in the Canadian high Arctic. However the focus of this presentation will be on the 1999 and 2000 Arctic campaigns, as these represent years with generally warm and cold stratospheric temperatures, respectively. Ozone and NO_2 total columns were obtained from the zenith-sky measurements, while the FTIR spectrometer measured ozone, HNO3, NO, NO_2, $ClONO_2$, N_2O, CH_4 and HF. These measurements will be compared with output from the Canadian Middle Atmosphere Model (CMAM). CMAM is a comprehensive chemistry-climate model incorporating radiation, interactive chemistry, gravity-wave drag, moisture, and momentum. It extends from the surface of the earth to about 96 km. Since CMAM is here run in climate mode, direct comparisons for a given day are not possible, and attention is focused instead on qualitative comparisons and processes. Correlation studies between various long-lived chemical species measured during both the 1999 and 2000 field seasons will also be presented.

2-D-3.7

Comparison of Atmospheric Trace Gases Measured Over Toronto Using a Ground-Based FTIR Spectrometer with Output from the Canadian Middle Atmosphere Model

A. Wiacek, D. Yashcov, J. Taylor, C. McLandress, K. Strong, T. G. Shepherd
Department of Physics, University of Toronto

A high-resolution Fourier Transform InfraRed (FTIR) spectrometer (Bomem DA8, manufactured by ABB Bomem Inc., Québec, Canada) is the primary instrument at the recently established University of Toronto Atmospheric Observatory (TAO). Continuous measurements of solar absorption spectra began in October 2001 for the purpose of building a long-term data set of key species related to climate change and mid-latitude atmospheric chemistry . The primary advantage of the FTIR measurement technique is that it simultaneously detects solar absorption features due to a broad range of trace gases, making it very useful for the determination of changes in atmospheric composition, and validation of model and satellite data.

The first vertical profiles and total column amounts over Toronto have been derived for CO, C_2H_6, HCN, CH_4, O_3, HNO_3, N_2O, NO_2, HCl, and HF from spectra measured from May through December 2002. The SFIT-2 least squares iterative retrieval algorithm (developed at NASA Langley Research Center, USA, and NIWA, New Zealand) was used, together with the HITRAN 2000+ spectral database, NCEP temperature and pressure profiles and volume mixing ratio *a priori* information. The results of this work will be presented and compared, where appropriate, with output from the Canadian Middle Atmosphere Model (CMAM) run in climate mode. This means that comparisons will be climatological. CMAM is a comprehensive 3-D chemistry-climate model incorporating radiation, interactive chemistry, gravity-wave drag, moisture, and momentum. It extends from the Earth's surface to approximately 96 km. When products of CMAM run in data assimilation mode are available, then more detailed comparisons on a day-to-day basis will be possible.

2-D-3.8

Field-Testing the MAESTRO Instrument from a High-Altitude Balloon

Caroline R. Nowlan [1], C. Thomas McElroy [1,2], David V. Barton [2], James R. Drummond [1], Robert B. Hall [2], Clive Midwinter [2], Kimberly Strong [1], and Aaron Ullberg [2]
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The MAESTRO (Measurement of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation) satellite instrument will accompany the Atmospheric Chemistry Experiment Fourier Transform Spectrometer on the Canadian satellite SCISAT-1. MAESTRO is a UV-visible photodiode array spectrometer that will make solar occultation and nadir measurements of the atmosphere to investigate the dynamical and chemical processes affecting ozone in the middle atmosphere. In addition to the MAESTRO satellite flight model, two other nearly identical spectrometers have been assembled. One of these spectrometers was launched on the MANTRA (Middle Atmosphere Nitrogen TRend Assessment) high-altitude balloon on September 3, 2002 from Vanscoy, Saskatchewan. During the flight MAESTRO-B collected sunset occultation spectra from a float altitude of 34 km.

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These spectra are the first atmospheric spectra collected by a MAESTRO instrument and are being used in the validation of MAESTRO on-orbit retrieval algorithms. Preliminary results for ozone and molecular oxygen (for use in pressure and temperature retrievals) will be presented.

2-D-4.1, 2
Parameterizing Turbulent Air-Sea Transfer in High-Wind, Spray Conditions
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U. S. Army Cold Regions Research and Engineering Laboratory

In high winds, breaking waves and whitecaps disrupt the ocean surface; spray proliferates. Because these spray droplets start with the same temperature and salinity as the surface water, they effectively increase the ocean's surface area and may thereby enhance the exchange of any constituent normally transferred across the air-sea interface. My interest here is in how spray affects the air-sea exchange of momentum and sensible and latent heat.

I will present a bulk turbulent flux algorithm that accounts for both the interfacial and spray routes by which sensible and latent heat cross the air-sea interface. The algorithm is appropriate for 10-meter wind speeds up to at least 30 m/s. To model the interfacial fluxes, the algorithm uses the COARE bulk flux algorithm (Fairall et al., 1996) with some high-wind-speed modifications. The spray component of the algorithm results from tuning Andreas's (1992) theoretical spray model with heat flux data from HEXOS, the experiment to study Humidity Exchange over the Sea (DeCosmo et al., 1996).

When spray droplets are formed, they accelerate quickly to the local air speed. This process extracts momentum from the wind. When the spray droplets ultimately crash back into the ocean, they transfer this momentum to the sea surface and therefore also, potentially, enhance the surface stress. The algorithm also models this exchange process. Although the spray momentum flux is small for wind speeds less than 30 m/s, it increases as the fourth power of the friction velocity, while the usual wind-driven, interfacial stress increases only as the square of the friction velocity. Consequently, as the wind speed approaches 60 m/s, in hurricanes for example, the interfacial and spray momentum fluxes become comparable.

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2-D-4.3
Storm Wind Study II - Air-Sea Interaction on the Grand Banks
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[4]*Meteorological Service of Canada*

The second Storm Wind Study (SWS-II) was a joint project among Environment Canada, Fisheries and Oceans Canada, and the Southampton Oceanographic Centre. The experimental area was the "Hibernia" site on the Grand Banks of Newfoundland, and the experiment covered the period 25 October 1997 - 9 April 1998. The Bedford Institute of Oceanography vessel CCGS "Hudson" was at the site from 17 November - 6 December 1997. A large set of meteorological and directional wave data was gathered from the Hudson and nearby buoys. These data are being used to investigate the reliability of ship- and buoy-borne sensors in the winter North Atlantic Ocean, and after that, to look at air-sea interaction processes in sea states from moderate to storm force (Beaufort 4 - 10). We will present and interpret the extensive and well-calibrated set of wind and temperature data and wind stress (using the turbulent dissipation technique) from SWS-2. The results exhibit remarkable similarities with earlier data sets collected in a wide range of marine environments.

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Air-Sea Interactions and Waves 2 / Interactions air mer et vagues 2

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2-D-4.4

Wave-induced Drift in the Coastal Region of the North-west of Baja California

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Waves and currents are being measured in the coastal region of the north-west of Baja California using acoustic Doppler current profilers and a HF CODAR-Type radar system. These measurements represent one component of a Coastal Oceanographic Observatory under implementation in the area of interest. Detailed measurements of waves and current profiles acquired at two sites with approximately 25 m and 14 m water depth are analyzed to detect the wave-induced part of the current field. Several events of relatively high waves ranging from 2.5 m to 3.5 m significant wave height are examined and a simple estimation of wave-induced drift is obtained. Direct measurements of these drift currents reveal some association with the groupiness nature of the wave field, when the analysis is made on a series of individual waves. A detailed comparison between time averaged surface current from the two adcp with the hourly radar measurements gives reasonably good agreement. The relevance of the wave-induced drift in larvae dispersion and other environmental aspects are also addressed.

2-D-4.5

The Effect of Coherent Structures on Air-Sea Gas Transfer

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An experimental study was conducted to investigate the coherent structures generated beneath wind waves and to examine their influence on air-water gas transfer rates. The experiments were conducted in a 9.2 m long and 1.2 m wide wind-wave flume at the Harris Hydraulics Laboratory at the University of Washington, Seattle. Measurements were made at a fetch of 5.5 m at wind speeds ranging from 4.5 m s^{-1} to 11.0 m s^{-1}. Digital particle image velocimetry (DPIV) was used to measure the two-dimensional velocity fields beneath wind waves in a plane parallel to the wind and bisecting the water surface. It is very important to accurately locate the air-water interface in the DPIV images in order to obtain accurate estimates of the near surface velocities. To accomplish this a second video camera was used to image the wind wave profiles where the laser light sheet intersected the water surface. Simultaneous and collocated water surface (skin layer) temperature measurements were made using an infrared imager and this data was used to detect microscale breaking waves.

Coherent structures are connected, large-scale turbulent fluid masses with a phase-correlated vorticity over their spatial extent. They are a ubiquitous feature of turbulent shear flows and are responsible for the large-scale transport of mass, heat and momentum (Hussain 1983). An algorithm was developed to detect coherent structures within the DPIV velocity fields and to compute their characteristics. As the wind speed increased from 4.5 to 11.0 m s^{-1}, the average maximum vorticity of coherent structures increased by approximately 40%, the average size of the coherent structures increased from 0.58 cm to 0.7 cm and the frequency of occurrence of coherent structures increased by a factor of four. In addition, the nominal diameter of the most energetic coherent structures increased from 0.8 cm to 1.6 cm and the fraction of the water surface renewed by coherent structures increased from 0.12 to 0.33.

The surface renewal model has been used by many researchers to estimate air-water gas transfer velocities of waterside limited gases (e. g. Asher and Pankow 1991). According to this model turbulent eddies near the water surface continuously renew the water surface by bringing parcels of deep fluid to the surface. Values of the gas transfer velocity predicted by applying the surface renewal

and thin film model were found to be in close agreement with measured gas transfer velocities. This close agreement demonstrates that combining the surface renewal model and the two-film model to predict gas transfer rates across a wavy air-water interface is a sound approach. The model predicted that 80% to 89% of the total air-water gas flux occurred across the fraction of the surface that was renewed by the observed coherent structures. Experimental and model results were then combined in order to demonstrate that microscale breaking waves were responsible for the bulk of the surface renewal.

2-D-4.6
Intercomparing Operational Wave Models
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Bedford Institute of Oceanography, Ocean Circulation Division

For coastal engineering studies, offshore oil platforms and marine transport safety, wave information is required in shallow water areas where wind growth, bottom dissipation and wave-current interactions may be important. An accurate and efficient wave model is essential. Although the standard numerical wave models WaveWatch-III (WW3) and WAM-PROMISE (WAM-P) can be considered state-of-the-art, their application for high-resolution coastal forecasts is very expensive computationally.

The nearshore third-generation wave model SWAN is a fully spectral model. Like WW3 and WAM-P, it solves the wave action density transport equation without a priori spectral constraints. It takes into account depth-induced wave-breaking and triad interactions. Triad interactions are not included in WW3 or WAM-P, although they are important for wave evolution in nearshore areas. Moreover, SWAN has additional attractive aspects, namely computational efficiency. Since it uses an implicit scheme allowing the use of large time steps (greater than the CFL limit).

The objective of this paper is to investigate and compare in more detail four composite model systems: (a) the nesting of SWAN in WW3, (b) SWAN in WAM (c) WW3 in WW3 and (d) WAM-P in WAM-P. Model results are compared with *in situ* and remotely sensed wave observations. Specific areas of interest are shallow water areas of Sable Island Bank, and the shelf area off Southwest Nova Scotia, as part of the GoMOOS (Gulf of Maine Ocean Observing System) initiative. Storms considered in this study include the 'Bomb' of January 2002. Observations of peak waves from this storm are used to inter-compare on one hand the capabilities the wave models to simulate extreme waves and on the other hand the capabilities of different instruments (DWR vs ADCP) to measure those waves in shallow waters. The coarse grid is (1° x 1°) resolution for the North Atlantic. An intermediate grid of (0.5° x 0.5°) resolution was nested within this coarse grid, for the Northwest Atlantic, and the same wave models as in the coarse grid were implemented. Finally, a fine-resolution grid of (0.1° x 0.1°) was nested within the intermediate resolution grid. In studies (a) and (b) above, SWAN cycle 2 was used here.

2-D-4.7
Simulation of Intense North Atlantic Storms: Coupling MC2 to Models for Waves and Sea Spray
Weiqing Zhang and William Perrie
Bedford Institute of Oceanography, Dartmouth, Nova Scotia

There is now a general consensus that the intensity of tropical storms and hurricanes is sensitive to the rates at which enthalpy and momentum are transferred between sea and air, particularly in the high-wind core of the storm. This is established by several studies, for example by Emanuel (1999, Nature) and Andreas and Emanuel (2001, JAS). However, while surface fluxes can be strongly altered by sea-surface wave drag or by sea spray, a comprehensive understanding of the impact of these processes has not been assessed in field programs. Nor has there been extensive analysis of the role of these processes in mid-latitude storms and extra-tropical intensifying cyclones, using operational numerical weather prediction models.

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In this study, a coupled atmosphere - ocean wave - sea spray system was used to simulate Northwest Atlantic Storms. Our focus is to evaluate the combined impacts of sea spray and wave drag on extra-tropical storm development, especially the intensity and the structure of the boundary layer. We are also concerned with the related impacts on the *surface waves*. The composite model system consists of the MC2 atmospheric model (v. 4.9.3), the operational wave model WaveWatch from NCEP, and a bulk-type formulation for the heat and momentum effects of sea spray from Andreas and DeCosmo (1999, 2002). The storms considered here include extra-tropical hurricane Earl (1998) and two intense, severe winter-storms: the meteorological "Bomb" from January 12-15, 2002, and the "Superbomb" from January 20-22, 2000.

While the overall impacts of sea-spray and wave drag on storm tracks are small, impacts on sea surface fluxes can be large. *By itself*, sea spray can cause increases in latent and sensible heat fluxes of up to about ~ 20% for Earl, and up to ~78% for "Superbomb". This tends to intensify the storm, with associated surface winds enhanced by as much as ~15m/s for "Superbomb", deepening the associated minimum sea level by as much as 11hPa. By comparison, *by itself*, associated wave drag leads to de-intensifying the storms, with wave-atmosphere effects on the order of ~3mb. These results are consistent with results found by Perrie and Zhang (2001, JGR) and Desjardins et al. (2000, JPO). Thus, the combined impacts of wave drag and sea-spray on storm intensity, to some degree, tend to cancel one another, as suggested by Andreas and Emanuel (2001, JAS). Resultant simulations, using the coupled model system, are shown to compare with available *in situ* and remotely sensed wind and wave estimates, for buoys off Atlantic Canada and in the NW Atlantic.

2-D-4.8

On the Atmosphere-Ocean Dynamics of Extra-Tropical Cyclones: Coupling MC2 to an Operational Ocean Model

Xuejuan Ren, William Perrie and Zhenxia Long
Bedford Institute of Oceanography, Dartmouth, Nova Scotia

The development and intensification of tropical cyclones and hurricanes tend to be controlled by internal variability and dynamics, in relation to interactions with the ambient environment through which they move. Emanuel (1999) suggested that hurricane intensities are dominated by mainly three factors: the storm's initial intensity, the thermodynamic state of the atmosphere through which it moves, and the upper ocean along the storm track. To investigate the atmosphere-ocean dynamics of mid-latitude North Atlantic storms, we coupled the MC2 atmospheric model (Version 4.9.3) to the Princeton Ocean Model (POM). Both models were implemented on rather high-resolution, for example 0.25º horizontal resolution for MC2, and 1/6º for POM. Coupling is achieved by passing SST (sea surface temperature) to MC2 from POM, and wind stress and net fresh water flux to POM from MC2. Case studies include: extra-tropical storm Earl in 1998, a meteorological "Superbomb" in January 2000, and Hurricane Erin 2001.

Ocean impacts on tropical storms are known to depend on factors such as a thin oceanic mixed layer, a slow moving storm (<6m/s) with large horizontal size, warm SST (sea surface temerature), and strong thermal stratification below the mixed layer (Schade; 1999, JAS). In this study we investigate mid-latitude storms. We show that storm-induced ocean surface currents, determined by surface wind stress, can be quite large, on the order of magnitude of the Gulf stream ~1.8m/s and to the right of the storm track. *On one hand*, mid-latitude marine storms such as Earl, occurring during the autumn, encounter a thin mixed layer, and produce a cold wake, resulting from storm-induced currents, with SSTs depressed as much as ~5o C to the right of the storm track. The impact of coupling is enhanced if the storm propagation speed is small, as in the case of Erin, to as much as 10hPa, for minimum sea level pressure. *On the other hand*, winter storms such as "Superbomb" occur when the mixed layer is quite deep, and impacts on SSTs and the upper ocean temperature profile are relatively very minor, although storm-induced surface currents are shown to be still quite strong.

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3-A-1
Evaluation of Forecasts of High Impact Weather
Harold E. Brooks
NOAA/National Severe Storms Laboratory

Forecasts of high-impact weather, particularly when the event is rare, are an important, but challenging, problem in operational meteorology. Evaluation of those forecasts is also an important, but challenging, problem. Much of the value of a public weather service comes in its ability to provide information so that decision-makers can make better choices in high-impact situations.

Historically, in meteorology, most of the emphasis in forecast evaluation has been on the relationship between forecasts and observed weather. In recent years, however, the focus has widened to the relationship between the forecasts, the weather, the users, and the users' decisions. This adds layers of complexities on top of the problem. Techniques that are relevant to estimating the value of forecasts to users have been developed over the years in disciplines outside of meteorology, such as medical imaging, machine learning, and information retrieval.

I'll review some of these approaches and discuss the relevance to meteorological forecasting.

3-A-2
Air Quality Prediction: An Overview of MSC's Program
Pierre Dubreuil
Atmospheric Environmental Protection, Meteorological Service of Canada

More and more Canadians rely on air quality forecasts to help them make healthy and environmentally friendly decisions about their daily activities. This presentation will deal with the various drivers behind the national air quality prediction program and the policy and scientific challenges that the MSC faces in developing the program.

MSC has provided urban air quality advisories since 1993, and beginning in Southern New Brunswick in 1997, has significantly expanded its air quality prediction services. The toolbox that supports these products has been steadily improved by developing and applying numerical and statistical models and by taking advantage of local partnerships and synergies. MSC is also working closely with Health Canada and stakeholders to improve what information is communicated to Canadians and how it reaches them. The revision of the air quality index is a related project that is intimately connected with the forecast.

The presentation will lay the ground work for a special session in afternoon by providing a historical, scientific and governance context for air quality prediction in Canada.

3-A-3
SHEBA: The Surface Heat Budget of the Arctic Ocean
Donald Perovich
CRREL, Hanover, NH

Results from global climate models indicate that the initial impact of greenhouse warming will be greatest in the Arctic and that the warming will be accelerated by ice-albedo feedback and cloud radiation feedback mechanisms of the sea ice cover. These feedbacks provided the motivation for SHEBA; a large, interdisciplinary research program examining the surface heat budget of the Arctic Ocean. SHEBA has two broad goals: to understand the ice-albedo and cloud radiation feedbacks and to use this understanding to improve climate models. The centerpiece of SHEBA was the year-long drift of the Canadian Coast Guard Icebreaker Des Groseilliers from October 1997 to October 1998. During this experiment an integrated dataset was acquired including measurements of atmospheric profiles of temperature, humidity and wind speed; cloud properties; longwave and shortwave radiation fluxes; surface albedo; shortwave extinction in the ice; snow depth and snow properties; ice mass

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balance and ice morphology; the thermohaline structure of the upper ocean; and the turbulent energy exchange between the atmosphere, ice and ocean. This comprehensive dataset has been reduced and analyzed. It is now being used to understand the processes governing the surface heat budget, to develop and test parameterizations suitable for climate models, and to evaluate single column models. A major legacy of SHEBA is the observational dataset documenting the air-sea-ice column over the SHEBA year. These data are available online for use by the scientific community.

Session 3-B-1

Operational Meteorology 1 : Performance Measurement / Météorologie opérationnelle 1 : mesure de la performance

Chair / Président : Stuart Cober

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3-B-1.1

Comparaisons entre les performances des modèles de prévisions des grand Centres / Comparison of Model Performances for Leading NWP Centres

Tom Robinson
Centre Météorologique Canadien / Canadian Meteorological Centre

Les scores de 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 par courriels 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, et aussi contre observations (radiosondes) pour les champs de hauteur, de température et de vent.

Ces comparaisons incluront les résultats du Canada (CMC), du Centre européen pour les prévisions météorologiques à moyen terme (CEPMMT), des États-Unis (NCEP), du Royaume-Uni (UKMetO), de l'Allemagne (DWD), du Japon (JMA) et de la France (Météo-France) pour les prévisions de 24 à 240 heures.

Si le temps permis, les scores de vérification de PQP des modèles seront présenté.

NWP model verification scores 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, and against observations (radiosondes) for height, temperature and wind fields.

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

If time permits, verification scores comparing model QPFs will also be presented.

3-B-1.2

Verification of the Canadian Ensemble Prediction System

Jacques Montpetit and Laurence J. Wilson
Meteorological Service of Canada, Montréal, Québec

Ensemble weather element forecasts consist of a set of possible values of each weather parameter at each location and each valid time. Verification of these forecasts presents the challenge of comparing in a systematic way the distribution of possible forecast values with a single observed value at each forecast location and time. Methods which have been proposed to verify ensemble distributions include the continuous form of the rank probability score, the rank histogram (Talagrand diagram), and a probability-based score proposed by Wilson et al. (1999).

As part of a larger project to develop a comprehensive verification system for the Canadian Ensemble Prediction System (EPS), we have been testing the method of Wilson et al. (1999) on the operational EPS forecasts issued by the Canadian Meteorological Centre (CMC). In this method, the performance of the EPS is estimated from the conditional probabilities that the actual observations occur given the probability distribution forecasts. A skill score is formulated by comparing the conditional probabilities of the observation given the EPS distribution with conditional probabilities given the

climatological distribution of the weather element. Tests were carried out using forecasts data for the period of January to December 2002.

Rather than using the discrete EPS distribution, appropriate distributions are fit for each weather element, for example the normal distribution for 2m temperature and the gamma distribution for wind and precipitation amount. Conditional probabilities are estimated from the fitted distributions.

The presentation will include some theoretical background, a description of the database and methodology, and a discussion of the most recent results available at that date.

Wilson, L. J., W. R. Burrows, and A. Lanzenger, 1999: A Strategy for Verification of Weather Element Forecasts from an Ensemble Prediction System. Mon. Wea. Rev., 127, 956-970.

3-B-1.3
Verification
Phil Chadwick
MSC

Recent Advances in Severe Weather Verification
The use of verification to diagnose the current state of the science and to feedback constructively on the design of the Severe Weather Program, is presented.

Spatial Verification.
The principles and methodology of verification at stepped spatial scales are displayed using severe summer weather verification statistics from 1987 to 2002. Sample products and applications of Spatial Verification are suggested. In particular, the optimal scale of prediction given the current state of the science, for severe thunderstorms over Southern Ontario is estimated. This scale of reliable prediction can then be used to improve client products and services

Temporal Verification.
The sensitivity of verification scores to the lead-time required to produce a "hit" has been examined using the severe summer weather verification statistics from 1997 to 2001. The decrease in verification scores as the required lead-time is increased, can be used to determine the actual state of the science of severe weather prediction.

The Season Convective Index Verification results are a function of many factors. The Season Convective Index (SCI) is a simple quantity that compensates the annual verification scores for the predictability of the events that occurred in a particular period of time. The prediction of an event invloves answering the important question of "if", "when" and "where" of the severe weather event. These quantities are challenging to answer for "pulse" type thunderstorms while they can be determined with some accuracy for supercell events. The verification scores over the period of the Ontario Severe Weather Program have been compared to the Season Convective Index for the same period. A high degree of correlation has been found. Year to year variations in verification scores is a strong function of the type of events that characterized the season.

Probability of Event Detection.
The probabilty that an event will be detected is a strong function of both road and population densities. It is suggested that up to 85 percent of severe events go unreported. This indicates that verification results that do not consider the the probability of event detection , do not portay the actual verification results. The case for an estimate of the probable verification results including "unconfirmed" severe events based on radar and satellite data is made. The actual verification results would be somwhere between the verification completed using only confirmed events and the "unconfirmed" verification result which would include all severe signatures from our remoting sensing network.

3-B-1.4
Mesure de performance des prévisions météorologiques forestières
Michel Moreau
Environnement Canada - région du Québec

La mesure de performance des prévisions météorologiques devient un enjeu de plus en plus important dans un contexte où les nouvelles politiques et la technologie bousculent constamment nos méthodes de production. Une telle mesure est non seulement essentielle à démontrer l'utilité de notre service et stimuler l'équipe de production mais elle est aussi indispensable à une gestion éclairée des différents programmes météorologiques.

Le sujet proposé traite d'un schème de mesure de performance des prévisions météorologiques forestières basé directement sur les indices de danger d'incendie de forêt. Selon la méthode canadienne d'évaluation des dangers d'incendie, les indices forestiers reposent essentiellement sur certains paramètres météorologiques observées et prévues. Ainsi, la mesure de performance des prévisions d'indices offre l'avantage de mieux évaluer l'impact de nos décisions météorologiques en plus de fournir des conclusions beaucoup plus près des préoccupations de l'usager.

Notre méthode de mesure de performance qui est fondée sur la technique de tableaux de contingence, se veut simple et facile d'interprétation. Dernièrement, quelques ajouts ont été apportés au schème de vérification afin notamment, de pouvoir confronter la prévision officielle avec une seconde prévision générée par Scribe: un générateur de texte appelé à devenir un outil incontournable chez Environnement Canada. Le nouvel algorithme est capable de fournir une mesure objective et automatisée de la performance des prévisions d'indices forestiers sur une base quotidienne, mensuelle et saisonnière.

3-B-1.5
Application Of an Objective Method for Evaluating Weather Forecasts On the Canadian Prairies
Julian C. Brimelow
University of Alberta

The University of Alberta offers a third-year course titled "Weather Analysis and Forecasting". As part of the course requirement this year, the students had to undertake an objective evaluation of the short-term weather forecasts issued by the Meteorological Service of Canada (MSC) and The Weather Network (TWN) for five cities across the Canadian prairies. Between 5 and 7 students were randomly assigned to evaluate the forecasts for each city. For each day between 16 January and 16 February, the students downloaded and archived the Day-0 through Day-5 forecasts (and hourly observations) from the internet. The performance of the MSC and TWN forecasts during this period were evaluated using a measure-orientated approach. A technique specially designed to objectively quantify the overall performance of each forecast in terms of selected weather elements was also employed. By undertaking this research project, students gained an appreciation for the complexities and difficulties involved when both issuing and evaluating forecasts. Further, the project also afforded students the opportunity to become actively involved in monitoring the weather during the observation period and apply their knowledge to real-world conditions in real time. We will present statistics concerning the forecast performance of the MSC and TWN forecasts for each of the cities, and will also discuss the effect of distance from the Winnipeg office on the forecast skill.

3-B-1.6
Some Issues on Probability Forecasting
Ramon de Elia and René Laprise
UQAM/Ouranos

Probability forecasts has already existed for over a century in some weather prediction centers, but in the last years a particularly strong discussion on the topic is taking place. This is mainly due to the

Session 3-B-1

Operational Meteorology 1 : Performance Measurement / Météorologie opérationnelle 1 : mesure de la performance

Chair / Président : Stuart Cober

Wednesday 4 June 2003

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Session 3-B-1

Operational Meteorology 1 : Performance Measurement / Météorologie opérationnelle 1 : mesure de la performance

Chair / Président : Stuart Cober

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fact that low atmospheric predictability diminishes the interest on deterministic forecasts, and hence there is a widespread sense that full probability forecasts may be a reality sooner or later.

Behind the apparent simplicity of forecasts broadcasted in probabilistic terms, the meaning of the announcement is not often shared by both forecaster and public. In this talk we will discuss about the different meanings that probability forecast may have, the presuppositions that are involved, and the common misinterpretations. Emphasis will be put on the distinction between *frequentist*, *classical*, and *subjective* interpretations of probability, as well as the criteria that define a good forecasting system such as *reliability*, *sharpness*, and *refinement*. The consequences for operational meteorologists of the disagreement among several objective probability forecasts will be briefly discussed. Suggestions for clarifications in the production and broadcasting of probability forecasting will be given.

3-B-1.7
Project Phoenix - Preparing Meteorologists for an Intensive Man-Machine Mix
Jim Slipec
MSC Winnipeg

Project Phoenix initially was a two-week experiment conducted by the Environment Canada's Prairie Storm Prediction Centre (PSPC) in Winnipeg, Manitoba. A team of three forecasters prepared noon and late afternoon public weather forecasts for Manitoba, Saskatchewan, and Alberta, without access to the guidance typically provided by numerical weather prediction output. The forecasts were verified against the official PSPC public forecasts, as well as the automatically generated SCRIBE forecasts based purely upon the RGEM model output, using a verification scheme developed specifically for the project. The Phoenix forecasters had access to the early morning SCRIBE forecast, based upon the 00Z model run from the night before, as well as a complete suite of real-time data. No additional model output or guidance of any form was available to the team. Over the two-week period, the Phoenix forecasters were successful in making improvements to the SCRIBE forecast out to 30 hours - the maximum time-step in the forecast process. The improvements were marginal at 24 hours and beyond, but became significant within a 24-hour range. For short-term forecasts of 12 hours or less, the improvement was dramatic. The Phoenix forecasts contained significantly less error than the comparable PSPC forecasts as well. As a result of that success, the PSPC adopted Project Phoenix as an official training program for all of its staff. In all, eight versions of Phoenix have now been run, with similar results.

Session 3-B-2

Chemical Meteorology and Air Quality 1 / Météorologie chimique et Qualité de l'air 1

Chair / Président : Philip Blagden

Wednesday 4 June 2003

mercredi 4 juin 2003

Room / Salle Panorama

3-B-2.1

Predicting Particulate Matter in Air Quality over Southern Ontario Using AAA

Ray J. Yang, Diane V. Michelangeli and Adam G. Xia
Department of Earth and Atmospheric Science, York University, Toronto

The influence of atmospheric aerosols on air quality and atmospheric chemistry has attracted wide attention. While various aerosol models have been developed, for example CMAQ in Model-3, GATOR by Jacobson and CAM by Environment Canada, a good and efficient scheme for exactly and efficiently treating complicated size and chemical component dependent aerosol microphysics and their coupling with gas chemistry is still very necessary. Here an advanced aerosol algorithm (AAA), which is capable of simulating the microphysics of size- and composition-resolved aerosols, and can be easily coupled with a gas chemistry module, has been developed. The module AAA was incorporated into the regional air quality model MC2AQ, and a simulation was undertaken for the period from July 1 to July 31 of 1999 for an 77x77 horizontal grid with 21.2 km resolution and 25 vertical layers up to 16 km with the model domain focussing on southern Ontario. The simulation results of particulate mass and chemical composition as well as the concentration of gas species are compared with ground-based measurements in this region. The results indicate the model can predict well the formation and evolution of particles from direct emissions and precursors gases. In the urban plume, the formation of particles from precursor gases such as SO_2, NO_x and VOCs, can greatly shape the particle distribution in size and chemical composition. The model is quite applicable for investigating particle evolution, evaluating regional air quality and studying the scenario of precursor emission reduction on particulate matter loading. Further research work will involve the integration of aerosol aqueous chemistry.

3-B-2.2

The Importance of Multiphase Reactions in Urban Tropospheric Chemistry

Surandokht Nikzad and Diane V. Michelangeli
York University, Toronto, Ontario

High ozone and particulate matter concentrations have been shown to cause human health and many other environmental problems. Heterogeneous and multiphase chemical reactions may play a major role in the chemical composition of the troposphere. In this study we update an existing box model named MOCCA (Model Of Chemistry Considering Aerosol), describing gas phase, aqueous phase and heterogeneous chemistry along with mass transfer between the gas and the aerosols. Photochemical reaction rates are assumed to vary with a semi-sinusoidal diurnal cycle. It is assumed that the temperature, pressure, and particle size distribution were constant. The total number density of particles in the base case (gas-phase only) is assumed to be $1.7\times10^{10}m^{-3}$. The liquid water content is calculated by integrating the particle volumes over all particle sizes with the constant value 4.22×10^{-11} m^3/ m^3 (4×10^{-5} g/ m^3). The results show that ozone is increased by 47% at steady state when aerosol phase chemistry is included, and decreased by 12% at steady state when heterogeneous surface reactions are included. The results also indicate that NOx is regenerated by HNO3 reactions in the aqueous phase. H2O2 reactions in the aqueous phase can also lead to increased HOx. Sensitivity studies have been carried out in order to assess the importance of some reactions. For instance, ammonia heterogeneous reactions may lead to a 9% increase in ozone gas concentration and a decrease by -26% when the whole aerosol chemistry is considered. Other chemical species are also investigated including HO_x, NO_x, VOCs and SO_2.

3-B-2.3

Global Atmospheric Cycling of Mercury

Ashu P. Dastoor and Didier Davignon
Modelling and Integration Research Division, Air Quality Research Branch, Meteorological Service of Canada

Unlike other heavy metals, mercury has been identified to have a long residence time (of the order of one year) which makes mercury a global pollutant. This is due to the fact that the most significant

form of mercury in the atmosphere, namely elemental mercury exists in gaseous form, it is chemically least reactive, has low solubility in water and takes part in volatilization process at the earth surface. Therefore, a global scale model is an appropriate tool to address the questions such as budgets, long-range transport, trans-boundary exchanges and polar pollution related to mercury in the atmosphere.

At Meteorological Service of Canada (*MSC)*, we have developed a high resolution Global/Regional Atmospheric Heavy Metals Model (*GRAHM*). *GRAHM* is an Eulerian Multiscale model and at present it is being used to investigate atmospheric mercury at global scale. The model solves dynamic equations for all meteorological processes and physio-chemical processes for mercury species. The model has variable resolution in vertical and horizontal. By making use of the variable resolution grid in horizontal, the model could be used for simulations on scales from global to urban by placing a high resolution window on a desired region. Gas and aqueous-phase chemistry, multiple-resistance based dry deposition, vertical planetary boundary layer diffusion, cloud-chemical interactions using detailed cloud schemes and wet deposition form the set of mercury processes included in the model. Global anthropogenic emissions of mercury for 1995 available from Global Emission Inventory Activity(*GEIA*) and natural/recycled surface emissions have been introduced in the model. The model was integrated for multi years to answer some of the questions related to mercury cycling in the atmosphere. Model description and results from the multi-year runs will be presented at the conference.

3-B-2.4
Tropospheric Chemical Data Assimilation
Richard Ménard[1], Alain Robichaud[1], Jacek Kaminski[2], and Emanuel Cosme[3]
[1]*Air Quality Research Branch, Meteorological Service of Canada*
[2] *York University*
[3] *McGill University*

A data assimilation effort is developing at the meteorological service of Canada in collaboration with universities, and involves both research and implementation for real-time air quality forecasting. While data assimilation has been used for operational weather prediction for decades its application for atmospheric chemistry is recent. Chemical data assimilation has specific challenges and objectives that are different from meteorological data assimilation.

One effort consist in the assimilation of long-lived constituents such as CO observed from MOPITT. This research is done using the GEM-Air Quality model developed by the Multiscale Air Quality Network led by Prof J. Connell at York University. We will also discuss the issue of source estimation. Another effort uses CHRONOS air quality prediction model and surface observations of ozone. Here we will discuss the implementation of a surface ozone objective analysis and its verification.

3-B-2.5
Aerosol-Cloud Interactions in Marine Stratus Clouds
Irena T. Paunova and Henry G. Leighton
Department of Atmospheric and Oceanic Sciences, McGill University

The indirect forcing due to anthropogenic aerosols introduces a great uncertainty in climate change estimates. The crude representation of both aerosols and clouds in large-scale models contributes to this uncertainty. Limited area models, however, allow for a detailed treatment of aerosols and clouds and therefore provide a more suitable framework to study the aerosol-cloud interactions. In this study we use the three-dimensional Canadian Mesoscale Compressible Community (MC2) model where we include details of the aerosol spectrum and explicitly predict the mass and the number concentration of cloud and rain. A direct coupling between the cloud microphysics and the radiation in the model allows us to realistically simulate the effect of the aerosol-induced changes in clouds on the radiation budget. This way, we can better predict the indirect aerosol effect at the regional scale. The focus of the study is on midlatitude marine stratus clouds, as the marine stratus strongly influences the

radiation budget and because its albedo is susceptible to the aerosol. We choose a case of a single layer stratus cloud that occurred in the Bay of Fundy (near Nova Scotia), which was extensively observed by aircraft as a part of the Radiation, Aerosol and Cloud Experiment (RACE).

To link the aerosol spectrum to the cloud droplet spectrum we use an aerosol nucleation model. The initial aerosol spectrum consists of sulfate and sea-salt particles and represents a fit to observed aerosol spectra below marine stratus clouds during RACE. Using a simple one-dimensional (1-D) kinematic model coupled with the nucleation model and a double moment cloud microphysical scheme, we evaluate the sensitivity of the aerosol nucleation parameterization to the initial aerosol spectrum. We then run the MC2 model coupled with the nucleation model and examine the sensitivity of the modeled cloud properties to changes in the aerosol spectrum.

Experiments with the nucleation model showed that in conditions of high sulfate concentration (1200 cm^{-3}) and weak updraft (<1m s^{-1}), the large sea-salt particles significantly decreased the number of the activated sulfate particles by reducing the maximum supersaturation. Experiments with the 1-D model demonstrated that increased number of large sea-salt particles significantly reduced the cloud droplet number and resulted in an earlier onset of rain and more efficient rain forming processes. The observed high sensitivity of the sulfate number nucleated and of the cloud droplet number to the presence of large sea-salt particles demonstrates the importance of the competition between the sea salt and sulfate particles in the formation of marine stratus clouds.

We simulated the RACE stratus cloud at high horizontal resolution (3 km) with the MC2 model. The modeled cloud properties: position, thickness, liquid water content and temperature compare reasonably well with satellite imagery and aircraft observations. Therefore, the case represents a realistic framework for a sensitivity study of the aerosol-cloud interactions in marine stratus clouds. The nucleation parameterization and a double moment cloud microphysical parameterization are being implemented in the MC2 model. We intend to simulate the physical processes that govern the aerosol-cloud interactions in the RACE cloud and we will present the results of the sensitivity of the modeled cloud properties to changes of the aerosol spectrum.

3-B-2.6
Testing a Isoprene Mechanism and Chemical Solvers
John C. McConnell, Hao Wu
York University

Isoprene and other hydrocarbons from biogenic sources are important species in atmospheric chemistry because of their reactivity and frequent high abundance. At large concentrations they can affect OH levels and ozone production. A complete suite of reactions to characterise the destruction of isoprene in the atmosphere by OH, ozone and NO3 could include over 2000 reactions. Currently the ADOM isoprene mechanism used in MC2-AQ and other air quality models is very limited and possibly misleading. Thus, in order to improve the ability of MC2 to characterize more accurately the isoprene concentration, a new isoprene oxidation scheme, known as the Mainz Isoprene Mechanism(MIM) [*Rolf von Kuhlmann (2001)*], is being introduced into MC2-AQ. In this talk we compare the impact of ozone generation, OH concentrations, NOx levels and generation and storage of PAN-like species with the old and new schemes for urban and background conditions. In addition, to solve the chemical equations, which are stiff ordinary differential equations a fast Rosenbrock method [Verwer et al. (1999)] was tested against Newton's method which is currently used in MC2-AQ. Some results from these tests will also be presented.

Session 3-B-3

Women in Science and Engineering / Les femmes en sciences et en génie

Chair / Président:

Wednesday 4 June 2003

mercredi 4 juin 2003

Room / Salle Chaudière

3-B-3.1

The Role of Women in Meteorology and Hydrology in the Activities of the World Meteorological Organization

Martha McCulloch
National Prediction Programs, Meteorological Service of canada

The World Meteorological Organization (WMO) conducted a survey on the participation of women in the fields of Meteorology, Hydrology and related Geophysical Sciences in 1997, and followed up with an International Expert Meeting in Bangkok, Thailand (December 1997). The participants reviewed the role and progress of women in meteorology and hydrology, and examined problems and challenges for women pursuing these careers. Recommendations from this Conference were approved at the WMO Thirteenth Congress in 1999, and covered topics such as Education and training; career and promotion opportunities; work environment policies and practices; participation by women in the work of the WMO; and representation of women in the work of WMO and in the Secretariat.

A second survey was subsequently made, and a second International Conference held in Geneva, 24-27 March, 2003, to review progress made towards implementing the Bangkok recommendations and to create a workplan for future efforts. Key topics discussed were breaking through the glass ceiling; experiences in other International Organizations; gender mainstreaming; experiences in national meteorological and hydrological services around the world and in WMO itself.

This presentation will cover a brief background on WMO, its history and mandate; a summary of the results of the first and second surveys on participation of women meteorologists and hydrologists in the work of WMO and their national agencies; feedback on the Second conference in Geneva; summary of the revised recommendations and the workplan for the future; and finally, some comments on strategies for working within the private and public sectors in Canada to give women the tools they need to overcome barriers and challenges.

The presentation will be followed by a panel discussion.

Session 3-B-4

Cryosphere /Cryosphère

Chair / Président : Anne Walker

Wednesday 4 June 2003

mercredi 4 juin 2003

Room / Salle Pinnacle

3-B-4.1

Canadian Long-Range Ice Forecasting (CLIF) Initial Work in the Gulf Of St. Lawrence

B. Miville [1,2], K. Wilson [1], B. Alt [3], A. Tivy [3], T. Carrierres [1], R. Powers [1], L. Hache [1], G. Langis [1]
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[3] *Balanced Environments Associates, Ottawa, Ontario*

The Canadian Ice Service (CIS) currently forecasts freeze-up and break-up conditions for the Canadian Arctic and the East Coast of Canada for 0-3 months in advance. Forecasts are based on comparing current ocean-ice-atmosphere conditions with analog (like) years. Validation results have shown these predictions to be inconsistent by region and highly dependent on the experience of the ice forecaster. Client needs are increasing for more accurate and longer range guidance in the 3-12 month time frame, and these needs are being driven by:

- Increased fuel prices,
- Northern Oil and Gas initiatives,
- Predicted longer and more variable ice seasons due to climate change,
- Adaptation strategies for northern on-ice activities.

In 2002 the CIS conducted an extensive literature review, including interviews with experts, on the potential of regional long-range ice forecasting. Results suggested the usefulness of low-frequency atmospheric and oceanic variability for long-range ice forecasting. The CIS and the Canadian Centre for Climate Modelling and Analysis (CCCMA) are currently creating regional ice severity indices based on the CIS digitized ice chart archive (1968-2002) for comparison to synoptic meteorology and oscillation patterns. Based on recent work by Crocker and ongoing research by Miville, the following weekly, regional ice severity indices have been developed:

- Total Area Coverage (TAC)
- Total Area Extent (TAE)
- Total Ice Severity Index (TISI): cumulated ice coverage weighted by ice type.

This presentation will highlight ice trends in the Gulf of St. Lawrence region ice severity indices and show initial promising results in their comparison with pre-season (3 to 12 months) atmospheric and oceanic conditions such as sea surface temperature or atmospheric mean sea level pressure.

Research is continuing to complete ice severity indices for other regions, with more advanced statistical analysis between pre-season predictors and in testing statistical forecasting methods.

3-B-4.2

Examining shifts in sea ice time series from the Canadian Ice Services Digital Chart Database

B. Alt [1], G. B. Crocker [2], R. Chagnon [3], S. McCourt [3], T. Carrieres [3], A. Tivy [4], B. Miville [5], T. Agnew [3] and K. Wilson [3]
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The Canadian Ice Service (CIS) has produced weekly charts of sea ice conditions in Canada's coastal regions for over 30 years. The charts contain detailed information on sea ice extent, area, floe sizes and stage of development, and have been digitized and compiled in an Arc/Info GIS system. The content of this valuable ice climate database is described by Crocker et al. (in preparation). They

present an in-depth assessment of the accuracy of the information in the database. This analysis considers the changes in techniques and technology involved in preparation of the charts over the more than 30-year period of record. They have assessed patterns and trends in several of the ice parameters found in the database for nine different contiguous geographic regions. The database also provided the basis for the CIS Sea Ice Climatic Atlases for Northern Canadian Waters and the East Coast of Canada and for other ice, atmosphere and ocean research including: climate change and process studies, analysis of extreme seasons, model validation, and long-range ice forecasting development (Falkingham et al., 2002; Jeffers et al, 2002; Alt et al., 2002; Howell and Yackel, 2002, Agnew et al., 2001; Melling in press, Crocker et al, in preparation, Tivy and Sou, pers. com. and several presentations to this meeting, e. g. Agnew et al., Miville et al., and Tivy et al.). The database is updated in near real time and will thus be an ongoing resource for ice climatology and climate change studies; engineering analysis, long-range forecast research and operations; and model validation.

Time series from several of these studies will be examined for shifts in ice parameters or for shifts in the relationship of these ice parameters to ice-ocean-atmosphere conditions. Detailed analysis of specific shifts, (using various analysis techniques combined with an examination of original ice charts) show that some of these shifts are related to technical changes in the database while others appear to be related to changes in the ice-ocean-atmosphere. The focus of the presentation will be on the time series from the High Arctic Islands, however, the analysis is an important step in the on-going assessment of this valuable sea ice database and its application to sea ice research and operational activities.

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Crocker, G. B., Carrieres, T., Chagnon, R., McCourt, S., Agnew, T., and Lewis, J. E., Ice Climate, in preparation. Trends in Canadian Waters from the Canadian Ice Services Digital Database, Submitted to *Journal of Geophysical Research*

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Howell, S. and J. Yackel, 2002. Utilizing climate, time series SAR and Canadian Ice Service ice chart data for facilitating ship navigation in the western Arctic. Poster presented to the annual CRYSYS meeting, March, 2002, Victoria, B. C.

Jeffers, S., T. A. Agnew , B. T. Alt , R. De Abreu, and S. McCourt, 2001. Investigating the anomalous sea ice conditions in the Canadian High Arctic (Queen Elizabeth Islands) during the summer of 1998. *Annals of Glaciology*, **33**, pp 507-512.

Melling, H., in press. The Sea Ice of the Northern Canadian Arctic Archipelago. Submitted to *Journal of Geophysical Research.*

3-B-4.3

Performance Evaluation of Two Neural Network-Based Models for Predicting Sea Ice Concentration

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Artificial neural networks are computational models capable of solving complex problems through learning, or training, and then generalizing the network solution for other inputs. This paper examines the performance of two neural network-based models, which were developed for predicting the ice concentration in the Gulf of St. Lawrence in Eastern Canada. The first is a batch model which uses past ice information to predict future ice conditions, while the second model predicts the ice

conditions sequentially. It is shown that the performance of the two models is almost identical, as long as no abrupt changes occur to the ice conditions. If, however, the ice condition changes suddenly, only the sequential model is proved to be capable of predicting the ice condition without noticeable accuracy degradation.

3-B-4.4

On the Utility of Diurnal Measurements of Snow Covered First-Year Sea Ice Microwave Scattering for Estimating Surface and Climate State Variables

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Snow covered sea ice represents a significant component of the marine cryosphere and reliable approaches to monitor, measure and model its morphological and thermodynamic state at various times of the year have been developed using both numerical process models and remotely sensed data. Time series microwave scattering coefficients from calibrated spaceborne synthetic aperture radar (SAR) have demonstrated utility in providing high spatial resolution information on the evolving physical and thermodynamic state of snow covered first-year sea ice from winter through summer. This is primarily due to the strong seasonal and diurnal coupling between the surface energy balance and the physical and electrical properties of the snow-ice system. We will soon enter an era where the temporal resolution of time series SAR data (especially for near-polar orbiting platforms) will significantly improve, especially for the polar regions. This should first become evident in 2004 when RADARSAT-2 joins the ENVISAT-ASAR and ALOS PALSAR (and perhaps even RADARSAT-1) in collecting multi-daily observations of the surface. In this paper we use high temporal resolution in situ property data and microwave backscatter coefficients collected over a 3 year period (2000-2002) from the Collaborative - Interdisciplinary Cryospheric Experiment (C-ICE) near Resolute Bay, Nunavut. We use this data to investigate the utility of diurnal measurements of microwave backscatter from a calibrated SAR (RADARSAT-1) for estimating diurnal (and seasonal) changes to selected surface and climate state variables from a snow covered first-year sea ice surface.

3-B-4.5

Air Temperature, Snow Depth, and Permafrost Temperature, Mackenzie Delta Area, NWT.

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Air and near-surface ground temperatures have been measured for over 2 years at Garry Island, on the western Arctic coast, and near Inuvik, NWT. The installation at Garry Island is in low-centered tundra polygons, and at Inuvik in a peatland south of treeline dissected by ice wedges. The trees are scattered at the Inuvik site. Data are collected every two hours by miniature data logger. At Garry Island, for 1999-2001 the mean annual air temperature has been -13.3 C, and at Inuvik -12.2 C. At the coast, the amplitude of the annual air temperature series is about 5 C less than at Inuvik. The annual mean ground temperature is -7.6 C at Garry Island, a value confirmed independently by measurements on a ground temperature cable installed to 11 m depth. At the Inuvik site, the annual mean ground temperature is -0.2 C. The snow at the tundra site varies between 25 and 40 cm in depth in April and has a density of 0.4, while at Inuvik, the depth is 70 cm and the density 0.2. Ground temperatures at the two sites are similar in summer, but distinct under the contrasting snow covers in winter. The data illustrate the dominance of snow conditions in controlling regional variations in permafrost temperatures, and the critical influence of the taiga in altering the evolution of the snow pack by restricting drifting.

Session 3-B-4

Cryosphere /Cryosphère

Chair / Président : Anne Walker

Wednesday 4 June 2003

mercredi 4 juin 2003

Room / Salle Pinnacle

Session 3-B-4

Cryosphere /Cryosphère

Chair / Président : Anne Walker

Wednesday 4 June 2003

mercredi 4 juin 2003

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3-B-4.6

Snow Water Equivalent Retrieval over Canadian Regions Using Passive Microwave Satellite Data

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The Climate Research Branch (CRB) of the Meteorological Service of Canada has a long-standing research program focussed on the development of methods to retrieve snow cover information from passive microwave satellite data for Canadian regions. Algorithms that derive snow water equivalent (SWE) have been developed by CRB and university collaborators and validated for a number of landscape regions including prairie, boreal forest and taiga. The SWE algorithms are used with SSM/I data to generate regional snow cover products that are being used to support a number of research and operational applications. Maps depicting SWE distribution over areas in western Canada are produced on a regular basis each winter (e. g. weekly) using SSM/I data accessed in near real-time. These maps are distributed to a variety of users such as national and provincial water resource agencies, agricultural agencies, hydropower companies, and meteorological forecast offices to support their operational activities. The distribution of SWE maps by e-mail and the internet (State of the Canadian Cryosphere web site: *www.socc.ca*) has widened the range of applications for the products over the past few years. Within the Climate Research Branch, passive microwave derived snow cover information is contributing to research on snow cover and climate interactions, including the investigation on linkages between snow cover and atmospheric circulation and validation of climate models. Passive microwave derived SWE data sets are also provided to university collaborators within the Canadian CRYSYS (CRYospheric SYStem in Canada) project to investigate the climate and hydrological significance of snow cover variability at study sites throughout Canada.

This presentation will provide an overview of the status of passive microwave snow cover retrieval in Canada, and the related challenges for SWE algorithm development and validation. Examples of the regional snow cover products currently being generated with SSM/I data will be presented with descriptions of the various research and operational applications for which they are being used. Potential future enhancements to SWE retrieval with new satellite passive microwave sensors such as AMSR (EOS AQUA and ADEOS-2) will also be discussed.

3-B-5.1, 2
Interactions of Atmospheric Trace Gases with Ice: Heterogeneous Reactions and Scavenging
Jonathan Abbatt
Department of Chemistry University of Toronto

One of the major findings from the investigations surrounding the Antarctic Ozone Hole was the dramatic extent to which gas-phase composition can be altered by both heterogeneous reactions and scavenging processes that occur via Polar Stratospheric Clouds. Guided by these findings, in recent years there has been considerable emphasis placed on determining the extent to which analogous gas-particle interactions can affect the composition of the upper troposphere. In particular, cirrus ice clouds are widely prevalent and they have, at times, very high surface areas. In this seminar, a number of laboratory chemistry studies of gas-ice interactions will be discussed as they pertain to the chemistry of the upper troposphere. Three chemical processes will be discussed: 1. The scavenging of gas-phase nitric acid by ice clouds that may, after gravitational settling of the ice particles, lead to substantial redistribution of NOy species throughout the free troposphere. This process could then play a significant role in affecting ozone production rates. 2. The oxidation of sulfur dioxide on ice surfaces, via reaction with adsorbed hydrogen peroxide. From our laboratory studies, it appears as though this oxidation process will proceed at a fast enough rate in reasonably thick cirrus that the lifetime of sulfur dioxide will be controlled by this process and not by gas-phase reaction with the hydroxyl radical. 3. The scavenging of oxygenated organics by ice clouds. Findings from both our laboratory and others indicate that only fairly large gas-phase organics partition efficiently to ice surfaces. The smaller ones, such as acetone, that have been observed in the upper troposphere and are known to play a significant role in HOx production, will not be scavenged to a significant degree by cirrus clouds.

3-B-5.3
A Numerical Model for Polar Stratospheric Clouds and Stratospheric Chemistry
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A multi-dimensional stratospheric model for aerosols including detailed Polar Stratospheric Cloud (PSC) microphysical processes, heterogeneous chemistry and comprehensive gas phase chemistry is being developed to study the formation and evolution of PSCs and the effect of heterogeneous reactions occurring on the surface of PSCs on polar stratospheric ozone. The model can be used in parcel mode or one, two, three dimensions. Background sulfate aerosols, frozen sulfate aerosols (sulfuric acid tetrahydrate, SAT) , Type 1a PSCs (nitric acid trihydrate, NAT), Type 1b PSCs (supercooled ternary solution, STS), and Type 2 PSCs (water ice crystals) are all treated as interactive elements in the model. The possible microphysical processes included in the model are: uptake of HNO_3 and H_2O on background sulphate droplets to form Type 1b and evaporation of HNO_3 and H_2O from Type 1b to return background sulphate droplets; homogenous freezing of Type 1b to form Type 2 PSCs; heterogeneous nucleation of SAT to form NAT particles, and NAT to form Type 2 PSC ice; deliquescence of SAT to form Type 1b STS and melting of SAT to form background sulphate droplets. In addition, the model involves the growth of ice and NAT by H_2O and HNO_3 deposition, evaporation, coagulation, sedimentation and transport processes. A full gas-phase chemistry scheme, using SMVGEARII (Sparse-Matrix Vectorized Gear code) as the solver, has been included for the stratosphere and/or troposphere. Heterogeneous reactions of nitrogen, chlorine, and bromine compounds in and on sulphate droplets, ternary, and ice particles are considered in the model. In this paper, preliminary simulation results of sensitivity tests are presented to display the basic features of PSCs and their effects on polar ozone. Comparisons with satellite measurements will be discussed.

Session 3-B-5

Middle Atmosphere Measurements and Modelling 4 / Mesures et modélisation de l'atmosphère moyenne 4

Chair / Président : David Sankey

Wednesday 4 June 2003

mercredi 4 juin 2003

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Middle Atmosphere Measurements and Modelling 4 / Mesures et modélisation de l'atmosphère moyenne 4

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3-B-5.4

Atmospheric N_2O and its Isotopic Analogues: Elucidating the Role of the Stratosphere through Models and Measurements

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[4]*University of Copenhagen, Department of Chemistry*

Nitrous oxide (N_2O) is an important greenhouse gas and the main source of reactive nitrogen in the stratosphere. Yet despite its importance, the details of its budget remain illusive. Additional information which may help constrain N_2O source and sink terms is contained the abundance of N_2O species substituted with a rare N or O isotope. Using laboratory measurements and theoretical chemical models as input into an a three-dimensional chemical transport model, we have clarified the role of the stratosphere in effecting the atmospheric abundances of the isotopically rare species of N_2O (e. g., 14N15N16O, 15N14N16O, 14N14N17O, and 14N14N18O).

These modelling studies reveal that the two stratospheric sink reactions, photolysis and photo-oxidation, which act to enrich stratospheric N_2O in its rare isotopic analogues by 0.5-2%, are consistent with atmospheric measurements. Furthermore, this good agreement negates the requirement for any stratospheric in-situ source or process and allows for detailed flux-weighted 15N and 18O isotope budgets.

3-B-5.5

Measurements of the Mid-Latitude Stratospheric Photodissociation Rates of $O(^1D)$ And NO_2 during the MANTRA 2002 Balloon Campaign

Hongjiang Wu[1], Kimberly Strong[1], C. Thomas McElroy[2], Chris McLinden[2], Clive Midwinter[2], Robert Hall[2], David Barton[2]
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The solar irradiances on a horizontal surface, the brightness of the limb, and the apparent surface brightness below the balloon have been measured at different solar zenith angles using a photodiode array spectrometer. This instrument was flown on September 3, 2002 from Vanscoy, SK (52°N, 107°W) during the Middle Atmosphere Nitrogen TRend Assessment (MANTRA) 2002 campaign, a balloon mission to study stratospheric composition. The recorded spectra are used to estimate the photodissociation rates (J-values) for the production of $O(^1D)$ from ozone, and of the photolysis of NO_2 to form NO and O. Excited $O(^1D)$ can react with H_2O, H_2, and CH4 to generate OH radicals which play a critical role in initiating the oxidation of a variety of trace gases. The O atom released by the photolysis of NO2 in the near UV is the primary source of troposphere ozone through the reaction $O+O_2+M \sim> O_3+M$. The total column of ozone above the balloon derived from the solar irradiances, as well as a surface albedo, are used to correct the shorter wavelength spectra by fitting in a photochemical model. The total J-values of $O(^1D)$ and NO_2 from the combination of experimental data and modeled spectra will be compared with modeled values and those measured in previous experiments.

3-B-5.6

Can We Predict the Fall Turnaround in Zonal Wind over Vanscoy?

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Department of Physics, University of Toronto, Toronto, ON

It is well known that extratropical stratospheric zonal winds change direction twice per year. Less well known is exactly when that change in direction - commonly known as "turnaround" - will occur. There has been some interest in the springtime turnaround that occurs in March or April, because of

the high dynamic variability of stratospheric zonal winds during that time and the implications for polar ozone loss. The turnaround in late summer has drawn less attention. This event, however, is of interest to the atmospheric science community, specifically those involved in high-altitude balloon-based remote sounding. One such high-altitude balloon campaign, the Middle Atmosphere Nitrogen TRend Assessment (MANTRA), launches from Vanscoy, Saskatchewan (52°N, 107°W) to study summertime mid-latitude stratospheric ozone depletion. A brief climatology of turnaround will be presented, as well as a description and the results of our attempts at accurately predicting the late summer turnaround over Vanscoy.

3-B-5.7
On The Limitations of Trajectory-Following Photochemical Box Modelling
Kirill Semeniuk
York University, Toronto, Canada

Photochemical box modelling along air parcel trajectories offers a way to separate dynamical and chemical effects involved in processes such as ozone loss. It also allows comparison of different satellite measurements in the absence of coincident observations. However, this modelling approach rests on certain assumptions which call for more investigation. The longevity of air parcels depends on latitude, altitude and time of the year. This imposes limits on the domain of applicability. The criteria that determine whether an air parcel has been sampled more than once by observational platforms are also affected. Initialization of the photochemical box model is a challenge since only a small fraction of chemical species is observed. We use the comprehensive dynamics and chemistry of the CMAM GCM to test existing techniques such as "trajectory hunting" (Danilin et al., 2000).

3-B-5.8
Modelling Tropospheric Chemistry in the Canadian Middle Atmosphere Model
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Department of Earth and Atmospheric Science, York University

The exchange of chemical species between the stratosphere and the troposphere has a profound effect on the chemical composition of both regions of the atmosphere. Water vapour, methane, N_2O and a variety of chlorine containing compounds, that significantly affect the chemistry of the stratosphere, originate in the troposphere. In turn, the stratosphere controls the amount of UV radiation that reaches into the troposphere, which strongly influences the chemistry of the troposphere. Further, transport of ozone from the stratosphere to the troposphere represents a large term in the global budget of tropospheric ozone. This is to say nothing of the complex dynamical and chemical coupling between the stratosphere and troposphere that makes the upper troposphere / lower stratosphere such an interesting region of the atmosphere to study in its own right.
Given the coupling between the stratosphere and troposphere, part of the development of the Canadian Middle Atmosphere Model has been focused towards including a description of the chemistry of the troposphere, as well as the many physicochemical processes that affect the chemical composition of the troposphere. Currently the model includes a description of CH_4-NO_x chemistry, emissions of CO and NO_x at the surface from technological, biomass burning and biogenic sources and the removal of water soluble species from the atmosphere by precipitation. Recent work has focused on modelling a pair of radioactive tracers, ^{222}Rn and ^{210}Pb, which have been widely used to diagnose transport and wet removal in global models. A three year simulation of ^{222}Rn and ^{210}Pb has been run and compared with observations. An overview of the development of the tropospheric chemistry components of the model and results from the comparison of ^{222}Rn and ^{210}Pb with observations will be presented.

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Session 3-C-1

Operational Meteorology 2 : Forecasting Tools / Météorologie opérationnelle 2 : outils de prévision

Chair / Président : Isztar Zawadzski

Wednesday 4 June 2003

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Room / Salle Joliet/Frontenac

3-C-1.1
Observation and Nowcasting in SCRIBE
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Development Branch Canadian Meteorological Centre

The SCRIBE Weather Forecast Product Expert System is capable of generating automatically or interactively any type of weather products for a region or a specific locality. However, the data that feeds the system is produced only from numerical weather prediction (NWP) models or statistical models. Therefore, the SCRIBE product generator is totally unaware of recent weather events, and this limitation is particularly acute for weather products that are generated long after the model run. This "blind" effect would generally result in forecasts that are not as up-to-date in their first 18 to 24 hours, were it not for the adjustments made by the operational forecasters. One of the key impetus for the work presented in this paper was to minimize these necessary manual adjustments.

The Observation and Nowcasting SCRIBE sub-system actually under development will merge the SCRIBE forecast events with the latest local observations and very short range forecast data. Different algorithms are used to generate nowcast data: multiple discriminant analysis is used to generate probabilistic forecasts over the next 6- to 12-hours at a one hour time resolution of several weather elements reported in the hourly observations; vector motions are calculated and used to displace into the future radar echoes at a one hour time resolution over the next six hours based North-American radar composite imagery and NWP 700 hPa forecast winds; vector motions are also calculated and used to project into the future areas with lightning strikes at a one hour time resolution. A first prototype will be presented showing how surface observations, radar data and lightning data are processed to update the SCRIBE weather element concepts and how the different nowcasting algorithms are used to project observation data in the short term. Although it is too early to make objective verification, it is expected that this approach will allow to reduce by up to 50 % the time spent by forecasters to quality control the initial parts of the SCRIBE forecasts. Furthermore, the added value to the SCRIBE forecasts in the initial period is expected to be of the order of 5-10%.

3-C-1.2
Utility of a Blowing Snow Model for Operational Forecasts on the Canadian Prairies and Arctic
J. Hanesiak[1], J. Butler[1], A. Tat[1] and D. Baggaley[2]
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[2]*Prairie Storm Prediction Centre, Meteorological Service of Canada*

The performance of a blowing snow model (Piektuk) in predicting the occurrence of blowing snow as well as resulting visibilities is investigated in various Prairie and Arctic locations. Standard hourly meteorological data from 36 different stations between 1960 and 2001 are used to force and validate Piektuk. Only the months between October and April were investigated. All cases where coincident precipitation occurred were omitted from the analysis as we were only interested in cases with ground-blowing snow and the comparisons between modeled and actual cases would be most appropriate. This limitation allowed a maximum number of cases to be 25800 (Baker Lake) and a minimum number of 649 (La Ronge), between 1960 and 2001. Standard model runs consisted of using parameterized wind thresholds and visibility inherent in Piektuk, resulting in a Critical Success Index (CSI) range of 0.01 to 0.54 for predicting blowing snow occurrence. Higher CSIs generally occurred in Arctic stations. The model consistently over-predicted the occurrence of blowing snow at all stations, suggesting that the threshold wind speed was too low in most cases. Sensitivity tests were done by varying the wind speed threshold for all stations to show whether the CSI improved. Visibility prediction was generally quite poor and was investigated in two ways. Baggaley and Hanesiak showed in an earlier study that each station has a wind direction bias with respect to blowing snow occurrence. The performance of Piektuk is also examined using these wind direction biases for each station.

3-C-1.3

Evaluation Of Hail Size Forecasts Produced Using Prognostic GEM Model Soundings And Hailcast

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The Canadian prairies are prone to frequent severe thunderstorm outbreaks during the summer months. One of the major challenges facing forecasters is the lack of representative soundings. Specifically, there are currently only two sounding sites across the prairies and consequently, the data from these soundings are rarely representative of the antecedent severe thunderstorm conditions. A potential solution to this problem is to employ temperature, moisture and wind fields predicted by NWP models to extract prognostic soundings at a high spatial and temporal resolution. These forecast soundings can then be used as input for a coupled cloud model and hail model, such as HAILCAST (Brimelow et al., 2002, *Wea. Forecasting*, 1048-1062), to predict the maximum hail size on the ground. The objective of our research is to determine the feasibility of producing high spatial and temporal resolution forecasts of maximum hail size using prognostic GEM model soundings as input for the HAILCAST model. For each day between 1 May and 20 September 2000, contour maps of the maximum forecast hail size (valid for 21Z and 00Z) were computed for all three prairie provinces. The forecast hail sizes were generated by running HAILCAST on a Cartesian grid consisting of almost 1 500 GEM forecast GRIB soundings (from the 12Z GEM model run). Higher vertical resolution BUFR soundings for 54 selected locations were also used to run HAILCAST. The forecast hail size maps were then compared against surface hail reports, cloud-to-ground lightning and radar reflectivity data. While the scarcity of hail reports from Saskatchewan and Manitoba precluded an objective assessment of the hail forecasting technique for these regions, performance statistics for southern and central Alberta indicated that our technique showed promising skill for correctly identifying areas where there was a threat of hail or severe hail. Also, the forecast distribution of hail across the prairies for the summer of 2000 agreed very well with the observed distribution of lightning during the same period. Finally, the hail size forecasts generated using the BUFR soundings were superior to those generated using the coarser GRIB soundings.

3-C-1.4

Forcasting Fog By Coupling The 1D Boundary Layer Model COBEL With a Mesoscale Forecast Model

Stevie Roquelaure, Peter Zwack and Christian Page
UQAM

COBEL is a 1D boundary layer model wich is used to forecast fogs. For radiative fog, the synoptic conditions (high pressure, clear sky, low wind) justify neglicting mesoscale forcing (advections). But for general fog cases, especially in advection fogs, it is important to take into account advections and their effects. Therefore coupling COBEL with a mesoscale forecast model (for example NOAA's RUC model with 20 km horizontal resolution) will be necessary to obtain reliable fog forecasts. In this type of study, the concern is about the handling the mesoscale advections. We have to remove from the advection signal the high frequencies wich are generally contaminated by numerical computation.

We will present a brief description of COBEL and RUC models and coupling strategy. We will also present several fog cases.

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Operational Meteorology 2 : Forecasting Tools / Météorologie opérationnelle 2 : outils de prévision

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mercredi 4 juin 2003

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3-C-1.5
Doppler Radar-based Precipitation Estimates over Southern Ontario during the Spring/Summer of 2000
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Meteorological Service of Canada - Ontario Region

Storm rainfall accumulation maps based on Doppler data from the King City and Exeter weather radars are presented for 7 heavy rainfall events that occurred over southern Ontario in the spring and summer of the year 2000. A storm rainfall analysis based on quality-assessed surface rain gauge data from the MSC and Conservation Authority networks in Ontario is also presented. A reflectivity-based attenuation correction applied to the Doppler data improves the radar-based rainfall estimates when compared to the estimates from the rain gauges. The difference between the radar and rain gauge estimates in some of the cases are attributed to the effects of radome wetting. The possible influence of the choice of rainfall-reflectivity (Z-R) relation, the operational Doppler clutter suppression algorithm and radar calibration are also discussed. The benefit of a multi-sensor approach to rainfall estimation is argued.

3-C-1.6
From mm to cm...; A Study of Snow/Liquid Ratios over Quebec
Ivan Dubé,
MSC - Quebec Region

Snowfall density (or the snow/liquid ratio) is a parameter which has been somewhat neglected by the meteorological community. The systematic use of the "10 to 1" rule to convert the QPF (in mm) into snow accumulations (in cm) is a good proof of that fact. However, snow density is important or even essential in many sectors or applications (e. g. snow removal, transportation, construction, avalanche & hydrological forecasting, etc). The need for specialized precipitation forecasts is increasing so we should recognize the necessity to develop efficient ways of forecasting snowfall density in the near future.

The main objectives of this study were to develop awareness of this problem among forecasters and also prepare them to face existing and upcoming challenges with respect to precipitation forecasting. To do so, a climatological study of snow/liquid ratios based on near 500 events over 8 observing sites has been performed. Then, all the theoretical information available on the subject was used to identify the various physical processes which determine snow density ice-crystal growth, accretion, aggregation, fragmentation and change of phase. These processes are strongly dependent on several meteorological parameters such as: temperature profile, relative humidity profile, vertical motion, low-level winds and ground temperature. They also depend on the crystal type or " habit " (eg dendrites, plates, columns, needles).

Results from this climatological study and several others were then analysed and compared with theory. A good agreement was found between theory and observations, which confirms their usefulness in the development of new forecast tools. Existing diagnosis/forecast techniques were evaluated and found incomplete and inadequate. Several new tools have been proposed, leading to the development of a snow/liquid ratio forecast algorithm. This algorithm includes all processes and parameters involved and considers their specific impact with respect to each crystal type. It gives us the capability of diagnosing/forecasting snowfalls among 5 categories (very heavy, heavy, average, light, and very light snow), to which are associated a mean snow/liquid ratio, or conversion factor (4, 7, 10, 15, 20). Verification of the algorithm on over 200 cases has shown encouraging results (87% accuracy).

Beyond snow accumulations, other aspects of weather forecasting related to snow density were studied (e. g. impacts on blowing snow and hydrological forecasts). Future developments include: more verification, completion of climatology and integration into numerical models.

3-C-1.7

Operational Post Processed NWP Products: TAFtime and Thermobot

Steven Laroche[1], Alister Ling[2], Steve Knott[2], Bruno Larochelle[2]
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The Prairie Aviation & Arctic Weather Centre has developed several experimental forecast tools which are derived from site-specific NWP data. The work undertaken consists of post-processing on the model data, as well as the generation of graphical products that quickly and efficiently convey tailored information to the forecaster. This poster describes two of the experimental products, Thermobot and TAFtime. Thermobot is a GEM-BUFR automated thermodynamic spatial analysis for 48 hours available for the Canadian Prairies and Arctic and relays quick visualization of convective potential, cloud bases, tops for surface and non surface based convection. TAFtime is a GEM-BUFR automated timeline of critical aviation parameters designed for individual TAF sites. Some of the visualization includes, cloud base and tops, wind shear, climatological wind roses and surface wind. These semi operational products were created using an informal and rapid development cycle. The intent of the concepts is to help provide a concrete platform on which front-line operational forecasters are able to submit input into future tool/product development.

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Chair / Président : Isztar Zawadzski

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Session 3-C-2

Chemical Meteorology and Air Quality 2
Météorologie chimique et Qualité de l'air 2

Chair / Président : Ann McMillan

Wednesday 4 June 2003

mercredi 4 juin 2003

Room / Salle Panorama

3-C-2.1
Air Quality Forecasting in Atlantic Canada
Bill Appleby and Mike Howe,
Meteorological Service of Canada

In 1997, the Meteorological Service of Canada - Atlantic launched Canada's first daily SMOG Forecast Program in Saint John, New Brunswick. Since then, the Air Quality Forecast Program in Atlantic Canada has expanded to include all four Atlantic Provinces. This expansion was accomplished with the support and cooperation of a multistakeholder partnership including the provincial Departments of Environment and Health and a number of environmental groups. The focus of this presentation will be to highlight the program's implementation and operational challenges and subsequent expansion. As well, program performance and future initiatives will be discussed.

3-C-2.2
Forecasting Air Quality in the Lower Fraser Basin
Edward Lord
Meteorological Service of Canada, Pacific and Yukon Region

On June 6th, 2001, the Minister of the Environment for Canada, David Anderson, disseminated the first ground-level ozone forecast to residents of the Lower Fraser Basin thereby inaugurating the air quality prediction program in Pacific and Yukon Region. Since that date over 500 ground-level ozone forecast bulletins have been issued for this area. This presentation will describe how meteorologists at the Pacific Weather Centre in Vancouver prepare ozone forecasts using their knowledge of weather patterns in the Fraser Valley, guidance from Environment Canada's CHRONOS model, and locally developed statistical models. A performance evaluation of the forecasts for 2002 will be presented including an assessment of the interaction of the human forecaster with the guidance. Recent work on developing statistical models for forecasting PM_{10} and $PM_{2.5}$ concentrations in the Lower Fraser Basin will also be presented with a view towards including these pollutants in future air quality forecast bulletins.

3-C-2.3
MAQNET - Multiscale Air Quality Modelling Network Project
J. C. McConnell for the MAQNET team
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With the impact of CFCs on stratospheric ozone and their climate effects along with CO2 has come the realization that human beings can impact the environment on a global scale. On the other hand, air quality has often been viewed as a local or regional issue. But in the last 10 years or so has come a growing realization that air quality is actually a global issue: for example, once out of the PBL ozone has a 1-2 month lifetime, gases and particulates from forest fires and biomass burning contribute the global air quality burden: dust and pollutants from Asia can cross the Pacific while North America exports its pollution to Europe and beyond as seen both by satellite, aircraft and in-situ data. In order to enhance Canadian expertise in this area and general forecasting of air quality the Multiscale Air Quality Network, a consortium consisting of University and Government scientists, was set up and university support is provided by CFCAS and NSERC. Presently the core project within the Network is the addition of gas phase, heterogeneous and multiphase chemistry along with aerosol microphysics to the Canadian weather forecast model, GEM (Global Environmental Multiscale model). The associated meteorological dynamical and physical processes such as resolved transport, large scale convection, PBL, deposition currently use the time resolved data from the host model. One other important aspect of the core project is the assimilation of chemical species data from various sources ranging from satellites or surface stations. For the former assimilation of CO from the MOPITT instrument is a major target and this may also lead to an improved estimate of CO and related emission sources around the globe. An example of the latter data source is ozone measurements from surface stations which can be assimilated in to regional and global models. Various other process-oriented projects such as cloud interactions, signatures of time varying emissions, improvements in

multiphase chemistry, the interactions of air quality chemistry and meteorology in complex terrain such as the GRVD or even lake breeze phenomenon also contribute to the generation of expertise in this area. In this presentation, I will discuss the general goals of the Network and present some of the most recent results from the addition of gas phase chemistry and aerosol microphysics which is a version of CAM (Canadian Aerosol Model). Clearly the long term goals of the Network are to establish an interactive community for studying the various facets of air quality and to integrate with the measurement community both on a local basis, with such experiments as Pacific 2001 and also ground based networks such as AEROCAN. And also to anticipate the ingestion of chemical species from current satellites such as TERRA (MOPITT etc) and future satellites such as AURA, METOP etc in order facilitate quality forecasting on scales from urban, to regional and global.

3-C-2.4
A Multi-Scale Air Quality Model With Applications For Policy And Forecasting: CHRONOS
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The prediction of high tropospheric ozone concentrations associated with photochemical smog episodes is one of central problems in the ßeld of air quality modelling. This task poses significant difficulties because it requires a realistic representation of the complicated interactions between chemical reactions, biogenic and anthropogenic emissions, and meteorological processes. For modelling purposes, these processes are commonly represented in the Eulerian frame of reference in which the formation of ozone is governed by a set of the advection-diffusion equations with forcing terms representing chemical reactions, emission, and removal of atmospheric tracers due to wet scavenging. In this paper, we present the formulation of the Canadian Hemispheric and Regional Ozone and NOx System (CHRONOS) which has been designed for the prediction of atmospheric oxidants on both regional and hemispheric scales. The model simulates dispersion and complex chemistry of nitrogen oxides and volatile organic species using inventories of actual anthropogenic emission. The meteorological input for the model is provided by the Mesoscale Community Model (MC2), and alternatively, by the Global Environmental Model (GEM) which is the operational model at the Canadian Meteorological Center. The current version of CHRONOS has been extended to include the parameterization of unresolved mixing and wet scavenging of tracers. The model formulation as well as the description of the employed numerical methods are presented in the paper. The theoretical part is followed by the illustrations of the model application for the operational air quality forecast at the Canadian Meteorological Center and for the evaluation of emission control strategies in Canada. The paper is concluded by the discussion of the future developments of the system including both the particulate matter scheme and the data assimilation capability which will ultimately lead to the increase of the realism of simulations of photochemical smog events.

3-C-2.5
Effects of an Improved Gas Dry Deposition Formulation in Reducing CHRONOS Model Error
Alain Robichaud, Alexandre Kallaur, Januz Pudykiewicz, Richard Ménard and Richard Moffet
Canadian Meteorological Centre

The Canadian Hemispheric and Regional Ozone NOx System (CHRONOS) is the operational model for air quality prediction in Canada. The dry deposition module of CHRONOS model has recently been upgraded. The new module is basically a blend of the best elements of an upgraded Weseley scheme for dry deposition (Weseley, 1989, 1996; Weseley and Hicks, 2000; Robichaud, 1991; Robichaud, 1994) and the non-stomtatal resistance formulation of Zhang et al. (2002), Zhang et al.(2003). The new module is thus an improved multiple resistance model for gas transfer to the surface and replaces the previous scheme which has no time and spatial dependency for surface resistance. In the new scheme, both the stomatal and non-stomatal resistance are allowed to vary according to 1) hourly changes in meteorological variables and, 2) seasonal changes of basic parameters for five different seasons and 15 different vegetation species By comparing three different

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modules for dry deposition (base case (old version) and two new versions), it was found that during midsummer afternoons results are not sensitive to gas dry deposition probably being overshadowed by photochemical , advection and diffusion processes. However, at night in summer and for most of the time during winter months, dry deposition becomes more important and improving its formulation of dry deposition may play a major role in reducing model error. Verification of this new scheme using a CANADA/USA data base for surface ozone (data base being maintained by the US-EPA) has shown significant reduction of global bias and RMS error over most of North America during summer at night and major reduction of bias everywhere in North America at any time during winter months (data of approximately 1000 stations across North America during August and December 2002 were used in the verification process). The reduction of bias at night and during winter months has a positive impact on future data assimilation of ozone. As a matter of fact, the basic hypothesis of variational analysis used in data assimilation requires that the model bias be as small as possible and much less than the standard deviation of model error. With the new scheme, this hypothesis is less often violated making data assimilation a viable option in the CHRONOS model.

3-C-2.6

Quantitative Sampling of Ambient Aerosols at Egbert, Ontario Using AerodyneAerosol Mass Spectrometer

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The Aerodyne Aerosol Mass Spectrometer (AMS) provides real-time information on size and chemical composition of ensembles of aerosols from tens of nanometers to a few microns. An AMS was used to sample ambient aerosols at the Environment Canada Centre for Atmospheric Research Experiments (CARE), Egbert, Ontario from17 Sep - 26 Nov 2002. The mass concentrations and size distributions of various species (sulfate, nitrate, ammonium, organics and their sum) were obtained and compared with other equipments; Tapered Element Oscillating Microbalance (TEOM) and Differential Mobility Analyzer (DMA). Ammonium nitrate frequently dominated the measured components of the aerosol due to the relatively high ammonia emissions in the local area. Elevated levels of nitrate and sulfate observed during southerly and southwesterly winds indicated that urban activities and regional transport influenced the site. Three different periods with higher nitrate, sulfate and organics were selected and analyzed with the aids of meteorological data (wind direction, wind speed, temperature, relative humidity) and gaseous data (O3, NO, NOy). Furthermore, delta analysis technique was used to classify organics into different groups showing that traffic related organics dominated most of the time. Preliminary analyses showed that total mass concentrations from the AMS were lower than mass measurements from the TEOM, though the trends were similar. In addition, volume time series and mass distributions from DMA data were higher than AMS data. These differences could be attributable to a combination of large particles (d >~1000 nm not effectively transferred in the AMS inlet system) and refractory components that are not measured at the standard operating temperature of the instrument. Filter based measurements performed simultaneously will be analyzed to narrow down such discrepancy.

3-C-3.1, 2

Carbon Exchange from Canadian Peatlands - Perspective and Understanding

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Peatlands occupy about 12% of the terrestrial surface of Canada, yet store more soil carbon than all other land surfaces combined (as much as 150 Gt). This carbon has accumulated over a period of thousands of years as a small but persistent net gain as a result of the two much larger fluxes of photosynthesis and respiration/decomposition. Current understanding of the carbon balance of peatland ecosystems is based on a variety of disparate techniques. This presentation discusses the current state of knowledge about carbon exchange from peatlands and highlights the importance of recent studies using eddy covariance to measure the net carbon dioxide exchange directly. Examples from a long-term study at the Mer Bleue Bog are used to illustrate interannual variation in the carbon exchange and its sensitivity to climate factors is discussed.

3-C-3.3, 4

Modelling the Exchange of Energy, Water and Carbon in Peatland Ecosystems

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Peatland ecosystems store between 200 and 450 Gt C (10^{15} gC). It is estimated that peatlands constitute an annual sink of between 0.1 and 0.3 Gt C yr^{-1} but this is based on very few contemporary measurements. With the huge amount of carbon stored in peatlands and the close association between the hydrology, - i. e. saturation, of peatlands and climate, concerns have been raised about a possibility of a positive climate feedback involving peatlands: increases in temperature, and/or decreases in water excess in northern peatland could lead to increased carbon mineralization and a conversion of peatlands from a sink to a source of CO_2. To gain a greater understanding of the climate-hydrology-carbon coupling in northern peatland ecosystems we initiated, in 1997, the Peatland Carbon Study and this study is continuing as the eastern peatland initiative of the Fluxnet Canada. Our objectives are to measure and model the energy, water and carbon balance of northern peatlands. To study the climate - carbon association over the short-term, e. g. decades to several centuries, we developed a processed based peatland model, the Peatlands Carbon Simulator (PCARS). PCARS couples with the wetland version of the Canadian Land Surface Scheme (CLASS) and it contains a fairly complete description of photosynthesis, autotrophic, and oxic and anoxic heterotrophic respiration, allocates fixed carbon to above and below ground components of trees, shrubs, sedges and mosses, and outputs the loss of carbon as CO_2, CH_4, and dissolved organic carbon (DOC). This model has gone through extensive testing against the measure carbon fluxes at Mer Bleue peatland, the main site of the Eastern Peatland Station of Fluxnet Canada. PCARS reproduces the net carbon exchange well but over-estimates the disaggregated components of gross photosynthesis and ecosystem representation. To study the climate - carbon association over longer periods, e. g. decades to millennia, we developed a phenomenological model, the Peat Accumulation Model (PAM). This model is based on two coupled equations: one describing the net carbon input based on the association between ecosystem production and decomposition and the water table position, while the other equation solves for the change in water table position as a function of the change in the mass of carbon stored in the peatland, i. e. the peatland height, and the annual water balance. The model compares well with reconstructed carbon accumulation from the analysis of peat cores when an independent estimate of relative wetness is used to increase or decrease the precipitation input.

Northern wetlands contain ~30% of the world's terrestrial carbon store, resulting from the incomplete decomposition of plant material inhibited because oxygen diffusion is limited by water saturation of the soil. While this behaviour results in a sink for CO_2, anaerobic pathways of decomposition result in

wetlands being a large, but variable, source of CH4. Northern wetlands tend to be nitrogen-impoverished, therefore they are not an important source of N_2O. However, nitrogen deposition, peat extraction, and other land-use changes have the potential to alter their greenhouse gas (GHG) sink/source function.

Until recently, most of the studies on the atmosphere-biosphere exchange of greenhouse gases from northern wetlands were short-term and seasonal. In 1998 the Peatland Carbon Study began continuous measurements of the carbon dynamics of a northern peatland and developed several ecosystem models to be used in simulations of the response of peatlands to climate variability and change. The continuous measurements have established the dominant role of climate variability in determining the magnitude and sign of the fluxes of GHGs. The Peatland Carbon Simulator (PCARS) was developed to use either direct measurements or modeled climate from a land surface process model such as the Canadian Land Surface Scheme (CLASS) which has been modified to incorporate the physical attributes of wetlands as inputs. PCARS illustrates the relative importance of various components of the ecosystem in determining the inter-annual variability in GHG exchange. Evaluation of PCARS has helped identify significant gaps in our knowledge of peatland systems. A second, more phenomenological model, the Peat Accumulation Model (PAM), demonstrates the overall importance of precipitation in controlling decadal to millennial scale variations in sink/source strength of CO_2. The Canadian Global Coupled Climate Carbon Model (CGC^3M) Network is attempting to parameterize wetland processes for the inclusion in a global terrestrial ecosystem model for climate simulations, but it is a significant challenge to develop an efficient, yet realistic, wetland simulator for global scale modelling.

3-C-3.5

A Vertical Diffusion Scheme to Estimate the Atmospheric Rectifier Effect

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Magnitude and spatial distribution of the carbon sink in the extratropical Northern Hemisphere remain uncertain in spite of much progress made in recent decades. Vertical CO_2 diffusion in the planetary boundary layer (PBL) is an integral part of atmospheric CO_2 transport, and is important in understanding the global CO_2 distribution pattern, in particular, the rectifier effect on the distribution (Keeling *et al*., 1989; Denning *et al*.,1995). Attempts to constrain carbon fluxes using surface measurements and inversion models are limited by large uncertainties in this effect governed by different processes. In this study, we developed a Vertical Diffusion Scheme (VDS) to investigate the vertical CO_2 transport in the PBL and to evaluate CO_2 vertical rectification. The VDS was driven by the net ecosystem carbon flux and the surface sensible heat flux, simulated using the Boreal Ecosystem Productivity Simulator (BEPS) and a land surface scheme. The VDS model was validated against half-hourly CO_2 concentration measurements at 40 m height above a boreal forest, at Fraserdale (49° 52'29.9" N, 81°34'12.3" W), Ontario, Canada. The amplitude and phase of the diurnal / seasonal cycles of simulated CO_2 concentration during the growing season agreed closely with the measurements (r^2=0.752). Simulated vertical and temporal distribution patterns of CO_2 concentration were comparable to those measured at North Carolina tower. The rectifier effect, in terms of an annual-mean vertical partitioning of CO2 in the atmosphere, decreasing from the surface to the top of PBL, was found at Fraserdale to be about 3.56 µmol mol^{-1} . Positive covariance between the seasonal cycles of plant growth and PBL vertical diffusion was responsible for about 75% of the effect, and the rest was caused by covariance between their diurnal cycles. The rectifier effect exhibited strong seasonal variations, and the contribution from the diurnal cycle was mostly confined to the surface layer (less than 300 m).

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3-C-3.6

Energy Storage in a Highly-Developed Urban Environment

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Understanding the nature of energy partitioning at the surface of cities is prerequisite to gaining proper insight and ability to model their climatic environment. Of particular relevance in the urban case is the role of the net storage heat flux (ΔQ_S), which has been shown to account for over half of the daytime net radiation at highly urbanized sites such as an industrial site in central St. Louis and in the colonial central district of Mexico City. ΔQ_S depends on urban surface materials and structure and its nocturnal release is regarded to be a major contributor to the urban heat island. Knowledge of this term is also required in other applications; for example, to assess building climates and to model evapotranspiration, sensible heat flux, and boundary layer growth. Given the complex, three-dimensional nature of the urban surface and the inherent challenges associated with direct measurements of ΔQ_S, this heat flux is an understudied component of the urban surface energy balance (SEB). A field campaign was undertaken in the city center of Marseille, France with the aim of comparing the relative ability of several methods to estimate the magnitude and temporal variation of ΔQ_S. This locale provides an ideal environment for this research, because it has a warm, dry climate (hence sensible heat dominates) and massive urban development (hence a large thermal mass for storage), such that heat storage is likely to be a large part of the overall SEB. Estimates of ΔQ_S obtained from tower-mounted fast response instruments (the energy balance residual approach) are compared to approximations resulting from a simple parameterization scheme (Objective Hysteresis Model, OHM), a local-scale numerical model (the Town Energy Balance model, TEB), and a bulk thermal mass-surface temperature approach. Results from the 10-day intensive field study show promising agreement under conditions with little cloud cover and variable winds. In particular, the TEB model simulated hourly ΔQ_S fluxes well when compared with the residual values. The OHM model, that has been shown to work well in several other cities, is less well suited. Modifications to OHM to incorporate aspects of the urban structure (deep canyons and courtyards) and the strength of the regional airflow are needed to improve its performance. The bulk thermal mass-surface temperature method is laborious to use in practice. The role of storage in the SEB of this Mediterranean city is found to be large but less than originally anticipated.

3-C-3.7

Measuring Longwave Radiative Flux Divergence in an Urban Canyon

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There has been very little measurement of longwave radiation divergence since the urban studies of Fuggle, Oke and Nunez in the mid 1970's or the rural work of Funk in the early 1960's. Although radiative divergence has been widely ignored for sometime there is the belief that it may play an important role in balancing nocturnal energy budgets in a range of environments. For example, in urban environments surface temperature relates well to the energy balance whereas air temperature does not, even in non-turbulent conditions. This is probably due at least in part to the effects of longwave divergence. To help answer issues related to longwave divergence a new dual-channel radiometer (DCR) has been developed. The DCR, as the name implies, measures the directional infrared radiation in two wavebands and can, through differencing of the signals and further signal processing, give a direct measurement of longwave radiative flux divergence. The DCR was deployed for the first time as part of a larger study (BUBBLE) of the urban boundary layer of Basel, Switzerland. The objective is to further study the thermal regime of a city at the canyon scale. To this end, a street canyon was carefully selected, in the city of Basel. The canyon surface and air volume

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were instrumented, including turbulent and conductive fluxes, and standard meteorological variables in addition to radiation. A unique data set was obtained to allow the complete energy balance of the canyon system to be evaluated without the need to resort to using residuals to quantify the magnitude of the longwave radiative flux divergence. The experimental set-up and some preliminary results of this measurement campaign will be discussed.

3-C-4.1

Recovery of the Sea Ice Regime in the Canadian Arctic Islands from the Warm Summer Of 1998

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The summer of 2002 had record low minimum Arctic sea ice cover (Serreze et al., 2002) adding to the downward trend of about 7% per decade in summer sea ice extent over the past two and a half decades (Comiso, 2002). Despite the low summer ice cover over the entire Arctic, minimum sea ice cover over the Canadian High Arctic Islands was above normal in the summer of 2002 as it continues to recover from the record light ice summer of 1998. A similar contrast can be seen over the last 40 years of summer minimum sea ice conditions in the Canadian High Arctic Islands (Queen Elizabeth Islands and Parry Channel) back to 1961. This time series of minimum ice concentration or coverage was reconstructed from the Canadian Ice Service ice chart digital database and the Polar Continental Shelf Project ice atlas charts and shows no long-term trends to less ice. This is consistent with regional differences between the Eurasian side and the Canadian side of the Arctic Ocean found by others and is likely due in part to large-scale sea ice dynamics, which on average pushes the Arctic ice pack up against the Canadian Archipelago and the northern coast of Greenland.

Detailed examination of these ice charts back to 1961, shows that there were three very light ice summers in the high Arctic Islands: 1962, 1981, and 1998 during which large amounts of sea ice especially multiyear ice where removed from the Islands. After each episode the sea ice regime recovered quite rapidly (within two years). A detailed breakdown of the ice types suggests that recovery from light ice summers was a combination of intrusions of pack ice from the Arctic Ocean into the northern channels which had been cleared of semi-permanent multiyear sea ice and sea ice plugs and remnant first-year ice which did not melt after particularly cool summers following these light ice summers.

This presentation will discuss what this might mean for the Canadian Arctic Islands under a warmer climate provided these trends continue and in particular the prospects of a NW passage under a warmer climate.

3-C-4.2

Comparison of Sea-Ice Rheologies in Global Ocean-Atmosphere-Ice Models and the Impact on Decadal Variability

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Results from the first stage of the project, which investigates the influence of changing Arctic sea-ice cover on the Atlantic thermohaline and northern high latitude climate, are presented. Due to a changing climate associated with global warming, the time scales of interest are decadal to century scales.

Early results from two global ocean-atmosphere-ice models will be discussed. The first model is the University of Victoria climate model, with the GFDL Modular Ocean Model 2.2, an energy-moisture balance model for the atmosphere and the elastic-viscous-plastic rheology for the sea-ice. The second model is the "modified UVic" model in which the sea-ice is represented by the granular rheology of Tremblay and Mysak. Both models are forced with the NCEP daily winds from 1948 - present. The advantages and disadvantages of both models will be discussed, with the focus on the northern high-latitude climate regime shift in the late 1970s and the observed 1990s changes in the Arctic Ocean.

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3-C-4.3

An Albedo Parameterization for Sea Ice Models

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In the past, several approaches were done to approximate the albedo for sea ice models. Generally, these attempts involved parameterizations of measured values. The parameterization presented here is developed with a new approach. The equations are developed from theoretical studies and independent from any measurements. The parameterization considers the four sea ice components of open water, ice, snow and melt ponds as a function of zenith angle, thickness of ice and snow, and depth of melt ponds. Further, the snow parameterization includes a dependence of the snow density. A simple exponential approach including polynomials of order 4 divided into four spectral bands simulates the time evolution of the albedo. The new parameterization is represented as a set of equations for a non-melting and a melting environment controlled by a temperature threshold. In addition, the computation includes a function describing a snow grain size change during melting as a transition function. Two tests are carried out: 1) A simplified grid cell albedo calculation where the investigated area covers up to some thousands of square kilometers and in this grid cell there can be fractions of open water, ice, snow and melt ponds; and 2) an albedo calculation on a thermodynamic sea ice model developed within the context of the Sea Ice Model Intercomparison Project, SIMIP 2. Both tests show good agreement with observations and measurements reported in the literature.

3-C-4.4

Numerical Smulations of the Crculation in the Canadian Arctic Archipelago

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Numerical ocean models is used to study the freshwater fluxes through the Canadian Arctic Archipelago. The data coverage is relatively low in this area. Based on existing data from different datasets climatological temperature and salinity fields are constructed and used as forcing fields for the numerical model.

Other forcing includes tidal elevation used for boundary condition. Work is in progress to apply a nonlinear prognostic model, and eventual atmospheric forcing and sea ice will be included in the simulations. Focus in this presentation is the set up and validation of the models.

3-C-4.5

Arctic Polynyas and Climate Change Experiences from the NOW And CASES Research Networks

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The Canadian Arctic Shelf Exchange Study (CASES) and the North Open Water (NOW) polynya studies are/were both Canadian led international research networks which examine the relationship between sea ice variability and ocean/atmosphere carbon fluxes. These projects were completed under the auspices of the International Arctic Polynya Program (IAPP) of the Arctic Ocean Science Board (AOSB). In this paper we provide an overview of the NOW and CASES experiments from the perspective of scale dependant forcing of the sea ice from oceanic and atmospheric processes as a means of examining how the NOW and CASES polynyas may (or are) responding to climate variability and change.

Results show that the sea ice average areal extent and spatial distribution in the southern Beaufort Sea have been decreasing, at an alarming rate since 1978. The meteorological forcing of this reduction is evaluated through analysis of NCEP reanalysis data in periods where prolonged negative and positive anomalies in sea ice concentration persist. The results illustrate that sea ice dynamics and

thermodynamics can be influenced by subtle atmospheric and pressure pattern differences between the North Pacific and the Southern Beaufort Sea. In the North Water region we found that analysis of the same anomaly approach resulted in a complex pattern of increases and decreases in ice concentrations with an overall increase in ice within the NOW polynya. This counterintuitive result is explained through the role which atmospheric teleconnections have with the central Arctic basin sea ice and source material required for ice bridge formation in Nares Strait. We conclude the paper with a discussion of the importance of understanding polynya dynamics and in particular the role polynyas may play as early indicators of climate variability and change.

3-C-4.6
Are Polynyas Self-Sustaining?
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In this paper, 441 CTD casts from the North Water Polynya study were used to calculate geostrophic currents between the surface and 200 dBar surface during April, May and June 1998. Results for April and May indicated a surface intensified southward flow of 10 to 15 cm s-1 with a small return flow along the Greenland coast in agreement with direct surface measurements of Melling et al. (2001) and with surface ice drifts found by Wilson et al. (2001). Southward transports at this time were 0.4 - 0.55 Sv. In June, however, surface currents decreased markedly and southward transports declined to 0.1 to 0.35 Sv. The surface barometric pressure between Grise Fjord and Carey Islands showed a marked decline in the local north wind speed coincident with a linear decrease in sea surface air temperature differences from April to June. There was no evident decrease in air pressure difference between Resolute and Grise Fjord, indicative of the strength of the north wind over the eastern arctic in general. The results are consistent with present thinking that the NOW is primarily a latent heat polynya forced by dominant north winds. The idea is broached that the polynya may create its own micro-climate resulting from an anomalous low pressure region associated with surface buoyancy flux in the polynya and is pursued through the application of a simple geostrophic adjustment model that suggests two self-sustaining mechanisms. First, the frontal intrusion of the cold ambient terrestrial air mass drives a significant surface wind that transports frazil ice to the edge of the polynya before it can congeal. Second, it is shown that rotation restricts the penetration of the front into the polynya, essentially insulating the center from freezing temperatures.

3-C-4.7
Surface Cloud Radiative Forcing in an Arctic Polynya
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In the Arctic, where clear skies represent only 15% of the summertime atmosphere, clouds play a commanding role in maintaining the state of the cryosphere. Attempts to characterize the microphysical and dynamic structure of these clouds have been previously limited to aircraft studies with small spatial range and even smaller sample sizes. Ground-based lidars are relatively new and few in the Arctic, with only one instrument tasked for full-time tropospheric cloud profiling, located at the ARM (Atmospheric Radiation Measurement) Program's North Slope Alaska (NSA) site. Satellite measurements of cloud properties, though possessing adequate orbital repeat at the poles, have been hampered by instruments' low spectral resolution and difficulty in distinguishing the thermal signatures of cirrus from ice- and snow-covered surfaces.

A radiative transfer model, *Streamer* (Key, 2001), supplied with atmospheric temperature and relative humidity profiles compiled from in situ data, forecast models, and remote sensing retrievals is used to evaluate the surface radiative forcing response to variations in cloud microphysics. Within the *Streamer* framework, user-prescribed cloud liquid water content, particle radius, base height, depth, and layering define the overlying atmosphere. Input values are based upon data from the NSA site radar-lidar array in Barrow, Alaska, adjacent to the Barrow Coastal Polynya, and are further

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constrained by values observed during aircraft studies and the SHEBA (Surface Heat Budget of the Arctic) Project. Initial radiation sensitivity results indicate that particle phase, and consequently liquid water path, far outweighs aerosol and ozone loading, even during times of high volcanic input and Arctic haze.

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3-C-5.1

Comparison of Lidar Measurements of Mesospheric Inversion Structures with a General Circulation Model

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Mesospheric inversions layers are a well documented, large scale phenomenon. These features are extended in longitude and despite their temporal variability are evident even in nightly averaged temperature profiles. Despite their large scale structure they have not been documented in general circulation models. While suggestions have been made that gravity waves are responsible for the generation of the inversions, no theory has been directly tested against measurements and models.

Three runs of the Canadian Middle Atmosphere Model (CMAM) using different gravity wave parameterizations have been analyzed for the occurrence of mesospheric inversions. Mesospheric inversions appear to be a ubiquitous feature of the model, with little dependence on the choice of gravity wave parameterization. To further test the interpretation of the results as inversions, CMAM temperature profiles near London, Ontario were compared to the inversion frequency, amplitude and thickness of over 350 nights of measurements by the Purple Crow Lidar (PCL). The results compare favorably in both seasonal behavior and overall characteristics. Thus, it is reasonable to suppose that inversion layers are caused by processes explicitly represented in CMAM.

A theory based on wave saturation has been developed that specifically predicts the relation between the temperature amplitude and thickness of the inversion, as well as the relation of the lapse rate in the inversion layer to the background lapse rate. The theory is tested using temperature measurements from the CMAM and the PCL. Preliminary results indicate that either large scale (e. g. model resolved) gravity waves and/or tides obtain sufficient amplitude to generate the inversions seen in both the measurements and the model calculations.

3-C-5.2

Global Variability of the Mesospheric Temperature Field

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The latitudinal variability in the annual march of mesospheric temperatures at the 70-90 km height range is examined. The analysis employs multi-year Rayleigh scattering temperatures from the WINDII/UARS experiment and ground-based OH rotational temperatures obtained at middle and high latitudes. As required, tidal perturbations are also evaluated and accounted for in the determination of the global temperature field in the vicinity of the mesopause. Particular attention is paid to the nature and duration of the summer mesopause period.

3-C-5.3

Comparison Of The CMAM With Observation In The Mesosphere Region

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Mesospheric chemistry has been studied using the Canadian Middle Atmosphere Model (CMAM). The version of the CMAM used has a global domain extending from the Earth's surface to about 95 km and includes a comprehensive interactive chemical package from 5 to 95 km. A comprehensive comparison with observations of the chemical species and temperatures was conducted, with a focus

on the mesosphere. It was found that the simulated temperatures were lower than the COSPAR International Reference Atmosphere (CIRA) by 10~K throughout most of mesosphere, with an extreme value of 30$^\\circ$ at equinox. However, they are in better agreement (within 10 K) to the Halogen Occultation Experiment (HALOE) observations. The atomic oxygen and nitric oxide densities are in good agreement with observations of CIRA and HALOE near the model top respectively, and this confirms that the chemistry upper boundary conditions are quite reasonable. The simulated ozone densities/mixing ratios are lower than measurements for daytime conditions. The simulated nighttime ozone is in good agreement with CIRA below 0.20 hPa ($\sim$60 km). Above 0.005 hPa ($\sim$85 km), model ozone is generally lower than the Millimeter-Wave Atmospheric Sounder observations by a factor of two. In between these altitudes the model nighttime ozone is in reasonable agreement with observations but with a large discrepancy at low and high latitudes where the model maxima are larger than observations. The simulated water vapour is about 10\% lower than HALOE observations also with large differences at low latitudes and high latitudes. The simulated seasonal variations suggests that the model can reproduce the main features of the large-scale motions in the mesosphere. The discrepancies indicate either a lack of or inadequate parameterization of physical or chemical processes in the model version.

3-C-5.4

Equinox Transition In Airglow And Wind Observations

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The equinox transition refers to two transient features that occur in the annual variability of the mesosphere and lower thermosphere, with the following scenario. Winter is dominated by downward flow, leading to enhanced concentrations of atomic oxygen and thus high levels of airglow emission. These strong emissions are punctuated by large depletions associated with the highly variable winter dynamics, including stratospheric warmings. The minima of these fluctuations show a clear downward trend during the course of the winter. Summer is a time of less variability and weaker airglow emission associated with atmospheric upwelling. The spring transition is observed as a sudden depletion of atomic oxygen, where the high winter values rapidly change to those characteristic of summer, as the downwelling reverses. The fall transition, on the other hand, is a time when the atomic oxygen is rapidly enhanced, through the onset of downwelling, to the high winter values. Coupling to the dynamics is evident in that both transitions correspond to times of the reversal of the zonal wind, and further evidence of coupling is found as a short-term correlation between zonal wind and airglow emission rate. The transition effects are dominant at high latitudes, but extend somewhat below 40° latitude. At still lower latitudes the airglow shows a more semi-annual variation, perhaps associated with tidal influence. The scenario outlined is described using observations from WINDII, the Wind Imaging Interferometer on the Upper Atmosphere Research Satellite, and from ground-based airglow and radar observations at Stockholm and Kühlungsborn respectively.

3-C-5.5

Multi-year Tidal Trends in Mesospheric Atomic Oxygen Profiles derived from Remote Sensing of the Nightglow

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The use of satellite measurements of the volume emission rates of the hydroxyl airglow and the atomic oxygen greenline are used to infer atomic oxygen profiles of the mesopause region. We use data from the WINDII instrument that observed these emissions for a space of many years in the early to mid 1990's. The atomic oxygen derived from both emissions was combined for a total altitude range from 82 to 115 km which included several kilometres above and below the peak in concentration. Variations of the solar tide with latitude and altitude will be addressed under both equinox and solstice conditions and from year to year.

3-C-5.6

Non-Migrating Tides in the Extended Canadian Middle Atmosphere Model

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Non-migrating tides are ubiquitous dynamical features in the mesosphere and lower thermosphere of the Canadian Middle Atmosphere model (CMAM). In the past they have tended to be ignored, in part because it is difficult to observe them. It is now being realized that they are more significant than previously though and need to be included to properly understand the dynamics of the mesopause region. In this talk, the nature of these waves will be introduced and model results for wave 1 and wave 2 for March and June presented. The temperature amplitudes of these tides maximize the mesopause/lower thermosphere and are of the order of 1 to 10 K. For some modes the meridional structure remains relatively constant whereas for other modes it varies significantly during the month. Most tidal modes (including migrating tides) exhibit vascillations at periods near 6 or 10 days indicating the possibility of nonlinear effects. The superposition of the nonmigrating modes with the migrating modes has the result that locally diagnosed diurnal and semi-diurnal signatures such as might be undertaken at local geographical sites vary significantly. It appears that much of the tidal variability observed in the Earth's atmosphere at local sites is due to these interference effects.

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Session 3-D-1

Operational Meteorology 3 : Processes / Météorologie opérationnelle 3 : Processus

Chair / Président : Mike Leduc

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3-D-1.1

Thunder Down Under: A Tornadic Supercell In Sydney, Australia, And The Role Of Low-Level Boundaries

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Severe thunderstorms developed on the afternoon of 3 November 2000 during the Sydney 2000 Forecast Demonstration Project. One of these storms, a tornadic supercell, produced three tornadoes, damaging winds, giant hail and heavy rain causing flash flooding. Data from two Doppler radars, a surface mesonet, enhanced upper-air profiling, storm photography, and a storm damage survey were used to examine the complex low-level boundary interactions that led to the development of the tornadic supercell. In particular, gust fronts, the sea breeze front, and interactions between these fronts were found to be central to the initiation and enhancement of storms, the motion of storms, and the generation of rotation at low-levels.

3-D-1.2

On the Role of Drylines for Triggering Tornadic Storms in Alberta

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The dryline is a synoptic scale feature that appears as a narrow zone across which sharp moisture gradients exist, while temperature gradients are weak. Drylines have been identified as favoured zones for the development of thunderstorms over the southern plains of the United States. Our objective is to determine whether the occurrence of drylines have a similar role of triggering severe convection in central Alberta. In Alberta, the dryline develops as a low-level discontinuity caused by confluence of moisture-laden air (advected in a southeasterly flow) and warm dry air (advected across the Rocky Mountains). We investigated the evolution of drylines for two severe storms that spawned tornadoes: a) the Edmonton F4 tornado of July 1987 that claimed 27 lives and caused 250 million dollars of property damage; and b) the Pine Lake F3 tornado of July 2000 that claimed 12 lives and caused over 100 injuries when it struck the Green Acres lakeside campground. Our research indicated that the Pine Lake storm closely followed the dryline for several hours. However, for the Edmonton tornado case, there was no correlation with the location and evolution of the dryline. We conclude that the dryline may be a triggering mechanism for some severe storms, but not for all.

3-D-1.3

Downstream Weather Impacts Associated With Atmospheric Blocking: Linkage Between Low-Frequency Variability And Weather Extremes

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A common finding among scientific studies is that long-lived weather extremes are often associated with recurrent atmospheric flow anomalies. Persistent anticyclonic anomalies (i. e., blocking events) represent a difficult forecast challenge, severely limiting the skill of medium range forecasts. In this study we examine the linkage between low-frequency variability as expressed in terms of persistent anticyclonic anomalies and weather extremes in an effort to aid forecasters and decision makers.

Using the NCEP/NCAR reanalysis we identify persistent 500 hPa anticyclonic anomalies over the Northeast Pacific (37 events) during the boreal winter season between 1979 and 2000. This region is chosen owing to the high frequency of occurrence of persistent anticyclonic anomalies and the potentially significant downstream weather impacts which can occur over North America. The mean signature over the Northeast Pacific is a pronounced ridge at 500 hPa flanked by upper tropospheric

troughs both upstream and downstream. Our early findings for the Northeast Pacific region indicate a preference for persistent anticyclonic anomalies to occur during the neutral or cold phase of ENSO.

In our study of weather extremes we focus upon daily temperature and precipitation to address the question as to whether the statistical distributions of temperature and precipitation change during the Northeast Pacific blocking regime. In the region extending from northern British Columbia southeastwards to the southern Plains of the US we find a dramatic increase in the number of blocking days with daily temperature anomalies in the lower tercile of the long-term boreal winter distribution, 30-40% greater than expected. We also witness in this same region an increase in the occurrence of extreme cold days. Over western Alaska there is a dramatic increase in the number of blocking days with daily temperature anomalies in the upper tercile, up to 25% greater than expected. Two key regions show an increased frequency of heavy precipitation events during blocking, the US Southwest and the Ohio Valley and Southeast. For heavy precipitation events over the US Southwest, equatorward of the blocking ridge, the anomalous storm track and the associated southwesterly moisture transports ("pineapple express") are more prominent and extend eastward toward the US West Coast. Over the Ohio Valley enhanced ridging off the US East Coast a few days after block onset is associated with anomalous southerly moisture transports from the Gulf of Mexico.

3-D-1.4
Small Scale Asymmetries in a Landfalling Hurricane
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Landfalling hurricanes pose a significant threat to the coastal communities. Most of the damages are caused by low level small scale asymmetric structures such as convective cells and wind streaks. In this study, a landfalling hurricane was simulated using the high-resolution PSU-NCAR nonhydrostatic mesoscale model (MM5). It was found that the maximum convective precipitation occurs in different quadrants relative to the storm track before and after landfall. The formation of the precipitation asymmetries as well as the small-scale wind streaks are investigated.

3-D-1.5
A Comparison Between Eastern North American and Western European Fronts
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Several Eastern North American and western European fronts were studied in detail using DIONYSOS to determine which forcings were responsible for their motion and vertical motions. A summary of the results, which will be presented, show that there are significant differences between what are analyzed as fronts in Europe and eastern North American and that they are really not the same animal. To avoid confusion for both the scientific and user communities, a different method will be presented on how what we call "fronts" should be represented on weather maps.

3-D-1.6
Local Initiation of Deep Convection on the Canadian Prairie Provinces
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This study demonstrated that it is likely that local mesoscale circulations associated with highland areas or hills, and transient evapotranspiration discontinuities influence the timing and location of the initiation of deep convection across the Canadian Prairie provinces when synoptic-scale forcing is weak (e. g. weak horizontal winds and no frontal boundaries). Highland areas had a noticeable influence on the timing and location of deep convection. The cumulus congestus and cumulonimbus clouds that formed over these areas were, in all likelihood, initiated by anabatic wind induced

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mesoscale circulations with or without supporting land-land breezes. These clouds generally formed relatively early in the day (about 1630 UTC). In the prairie cropland region, over relatively flat agricultural terrain, transient evapotranspiration gradients within the dominant crop, spring wheat, influenced the location of the initiation of deep convection, and the average level of soil moisture in the root zone had a direct impact on the timing. Cumulus congestus and cumulonimbus clouds that formed over the ephemeral evapotranspiration gradients were, in all likelihood, initiated by land-land circulations. In general, as the root zone soil moisture levels declined from greater than 70% to less than 30%, the initiation of deep convection was delayed from about 15:30 to 22:30 UTC. This analysis has improved the understanding of local surface forcing on the development of deep convective cloud in the Canadian Prairie provinces. The identification of areas where deep convection is likely to be initiated with weak synoptic forcing will also aid in the forecasting of thunderstorms in this region.

3-D-1.7
A Reanalysis of Hurricane Hazel (1954)

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Hurricane Hazel, which struck southern Ontario during 15-16 October 1954, was one of the most deadly and destructive weather disasters in recent memory. The copious amounts of rainfall, associated with Hazel's extratropical transformation phase, produced severe flooding in the watersheds surrounding Toronto that resulted in more than 80 fatalities and extensive property damage. Several southern Ontario reporting stations received record large amounts of rainfall that have not been surpassed during the ensuing 50 years. The availability of global reanalysis gridded data and a high-resolution mesoscale model provides a new opportunity for us to understand the planetary, synoptic-scale and mesoscale structures associated with one of Canada's greatest weather disasters.

To understand the larger-scale structures of Hazel, we use the National Centers for Environmental Prediction (NCEP) global reanalysis data to document the potential vorticity structures associated with Hazel during its full life cycle from the tropical phase through its transformation to an extratropical phase. We compute anomaly correlations of sea-level pressure and 1000-500 hPa thickness anomalies (with respect to a long-term climatological mean) to search for similar-appearing synoptic-scale structures (analogues) during the past 50 years. Our search has produced three analogues to Hazel, and we distinguish the mesoscale details amongst Hazel and its three synoptically-similar analogues.

To understand the mesoscale dynamics associated with the full life cycle of Hazel, we use the MC2 (Mesoscale Compressible Community Model) to simulate Hazel. The NCEP global reanalysis data are used for the initial and boundary conditions. Our simulation has successfully reproduced the extratropical transformation of Hazel with its accompanying frontogenesis and heavy precipitation over southern Ontario. To understand the importance of specific synoptic-scale features, we test the sensitivity of Hazel's transformation to the details in the sea-surface temperature field. We also test the sensitivity of Hazel's development to an initialization with an improved structure of the offshore vortex of Hazel replacing the poorly-resolved vortex provided by the NCEP reanalysis.

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3-D-2.1
Emission Inventory Data Preparation for Air-Quality Modelling
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Anthropogenic and natural source emission rate data are one of the most important inputs for regional- and continental-scale chemical transport models (CTMs). National emission inventories of the so-called 'criteria pollutants' (SO_x, NO_x, VOC, CO, NH_3, PM_{10}, $PM_{2.5}$) are compiled by government agencies on a jurisdictional basis (i. e. state/county or province/census division) for a specified inventory year, and are reported as annual or, in some instances, seasonal or monthly emission totals. These national emissions data are not directly useable by CTMs, as these require the emissions to be (i) spatially distributed over a gridded modelling domain, (ii) temporally resolved to hourly emission rates, and (iii) chemically speciated to meet the particular atmospheric chemistry scheme being used by the CTM. In addition, the rates of emissions from vegetation, soils, and transportation sources depend on prevailing weather conditions, and models are thus used to calculate emissions from these sources using meteorology for the specific period being modelled. The Canadian Emissions Processing System (CEPS) has been used to carry out these data processing and modelling tasks in preparing emission data input for Environment Canada's suite of CTMs. The flexibility of CEPS has enabled it to meet the diverse needs of these CTMs, which are now able to carry out highly detailed simulations of atmospheric chemical reactions on increasingly finer spatial resolutions covering the whole of North America. This presentation gives an insight into the CEPS processing of 1990 Canadian and U. S. national emission inventories for input to the CHRONOS operational ozone forecast model and the use of CEPS to meet the need for a more detailed chemical speciation of the VOCs for modelling secondary organic aerosol formation in AURAMS, Environment Canada's CTM for size- and composition-resolved aerosol. The CEPS processing required for these two model applications is briefly reviewed and examples of the gridded emissions fields prepared will be presented.

3-D-2.2
START - An Atmospheric Transport Analysis Tool
Julie Dion
SMC - Québec Region

START (Suivi du Transport Atmosphérique Régional et Transfrontalier) is a sofware used for the analysis of source-receptor relationships based on the flow of atmospheric pollutants. It integrates trajectories from the Canadian Meteorological Centre (CMC) or from the Air Quality Research Branch (AQRB), and emission fields produced by the Canadian Emission Processing System (CEPS). START can compute the residence time of particles over a user defined grid. This data can then be used in calculating many types of statistics (PSCF for example). START can also calculate the maximum pollutant loading (for 20 pollutants) along a trajectory by multiplying the residence time of an air parcel by the emission rates over a grid cell. Both results can be used to trace back the source and/or path of pollutants affecting a particular site. A description of the START software and some results with respect to ozone and PM 2.5 will be presented.

3-D-2.3
Back Trajectory Analysis of PM2.5 and Ozone Behaviour in Southwestern Ontario
Carrie Lillyman, Thera Ip and Jeff Brook
MSC, Downsview, Ontario

The impact of various atmospheric transport directions on ambient fine particle (PM2.5) and ozone (O3) concentrations at several urban sites in the Greater Toronto Area (GTA) is examined for summer (May-September 1998-2001) and daytime (10AM-10PM) hours. Three-day back trajectories(four per day) from the Meteorological Service of Canada Hemispheric Trajectory Model (HTM) were paired with corresponding 6-hr average meteorological variables, PM2.5 mass concentrations measured

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using the Tapered Element Oscillating Microbalance (TEOM) method and O3 concentrations. This analysis builds on Brook et al. (2002) where south/southwesterly flow lead to PM2.5 concentrations 2-4 times greater than corresponding northerly flow. PM and Ozone concentrations are compared under the various flow conditions and under variable precipitation events. The effect of little to no precipitation versus significant precipitation (i. e. washout) on PM and ozone concentrations throughout southern Ontario will be discussed.

3-D-2.4
Multi-Episode Simulations Of Ground-Level PM And Ozone With AURAMS
V. S. Bouchet [1], L-P. Crevier [1], S. Menard [1], S. Cousineau [1] M. D. Moran [2], P. A. Makar [2], W. Gong [2], A. P. Dastoor [2], S. Gong [2], B. Pabla [2], L. Zhang [2]
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The development of AURAMS, A Unified Regional Air quality Modelling System, has been aimed at providing a integrated tool to study the formation of ground-level ozone, ground-level particulate matter (PM) and acid deposition, in support of policy applications. The chemical transport model describes the evolution of size-segregated, internally mixed aerosols, composed of up to 8 chemical species (sulphate, nitrate, ammonium, sea-salt, organic carbon, elemental carbon, crustal material and aerosol-bound water), and their interaction with gaseous co-pollutants in multiple phases. It is driven with meteorological fields from the Canadian forecast model GEM. As AURAMS is an episodic regional model, multiple episodes are being simulated to evaluate its performance. Ozone and PM interactions are studied during summertime episodes in eastern Canada and US (July 1995, July 1999), while wintertime PM behavior is investigated during the event of February 1998. Tests are also being conducted for western Canada. This presentation will discuss results from the various evaluations as well as future policy applications.

3-D-2.5
High Resolution Modeling of Lake Breeze and Its Effect on Air Quality
Zhuming Ying and John C. McConnell
Centre for Research in Earth and Space Science, York University, Toronto, Ontario

High concentrations of ozone and ozone precursors are observed in the vicinity of Lake Ontario. There has been some speculation that some of the increased ozone concentrations are attributable to the lake breeze circulation of the Lake. Several studies have been undertaken to study the effect of lake breeze circulation on air quality in southern Ontario. In this study, an on-line mesoscale air quality model, MC2AQ, is used at high resolution to study the influence of the lake-breeze circulation over Lake Ontario on the transport and generation of pollutants (especially ozone and particulate matter) in southern Ontario and north New York regions. Simulations are performed in a triply nested model with the finest mesh being 1-2 km. Numerical experiments are performed to simulate the development of lake breeze of the Lake Ontario. Preliminary analysis of both Lagrangian and Eulerian transport of pollutant will be presented.

3-D-2.6
Air Quality Prediction and Health: an Alternative Air Quality Index Formulation
David M. Stieb[1], Marc Smith Doiron[1], Philip Blagden[2], Richard T. Burnett[1]
[1] *Healthy Environments and Consumer Safety Branch, Health Canada*
[2] *Meteorological Service of Canada, Environment Canada*

Both the general public and specific target groups use information from air quality reports and forecasts to make decisions regarding mitigation of their exposure. The Air Quality Index (AQI), though widely available, has been criticized for failing to reflect simultaneous effects of multiple pollutants, and the occurrence of adverse effects at low levels of exposure. We developed a no-threshold, multi-pollutant AQI, based on the relationship of CO, NO_2, O_3, SO_2 and $PM_{2.5}$ with mortality in Canadian cities. Risk coefficients were applied to daily air pollution concentrations to

calculate multi-pollutant percent excess mortality, and results were scaled to a 0 to 10 range. The observed distribution of values was used to characterize days as low, medium, high, or extreme risk. Considerable day to day variability in the index value was observed and the percent of days falling in the high or extreme risk categories ranged from 0.3 to 33.2 among the cities considered. The new index was moderately correlated with conventionally-derived AQIs. Results did not appear to be sensitive to an alternative choice of risk coefficients. Additional efforts will be required to apply the index formulation to both real-time and forecasted air quality; to validate this formulation against one based on the association between air pollution and other health outcomes; and to most effectively utilize the AQI as a communication tool regarding acute health risks associated with air pollution

3-D-2.7
The Future of Air Quality Prediction in Canada
Gordon McBean
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Meteorological Service of Canada has initiated an air quality prediction program as an overall commitment to becoming an environmental prediction service. Subsequently, there has been ongoing research, development of statistical and numerical models and programs to support the air quality prediction component of the strategy . This presentation will deal with the possible contribution of air quality prediction to an expanded, comprehensive strategy for environmental prediction which could well encompass weather and climate, ice, water quantity and quality, air quality and weather-related natural hazards. There are opportunities to integrate such environmental prediction organizationally, through linking local-provincial-federal agencies and perhaps even to develop a national prediction agency as the hub for presentation of information and warnings to Canadians.

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Boundary Layer 2 : Simulation and Observation / Couche limite 2 : simulation et observation

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3-D-3.1
Concentration Fluctuations in Dispersion Through Obstacle Arrays
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The response of biological organisms to toxic gases is dependant on both peak concentrations and the duration of exposure. The perception of odors by the public, the probability of ignition of flammable mixtures, or the portion of a population that will experience toxic effects all require an estimation of time-varying concentration profiles at a fixed receptor. This study determined time varying concentration profiles in an obstacle array due to short duration plume emissions. The experimental configuration was designed to model an instantaneous point release of pollution in an urban landscape using rectangular shaped obstacles placed in a simulated atmospheric boundary layer flow in a water channel. The resulting data shows that as the distance into the array increases, the peak concentration decreases and the time of exposure increases. While this same relationship is also shown in an open space, for an unobstructed plume, the residence time of the plume in the array is greatly increased due to plume entrainment in building wakes. The increased residence time of a plume at ground level in an urban environment may sometimes cause a greater portion of those people who are exposed to the plume to experience toxic effects. The information obtained from this study can also be used to determine the length of time required for concentrations to decline to safe levels in street canyons.

3-D-3.2
Fast First-Order Wet Turbulence Model
Kyle Spyksma, Peter Bartello, M. K. (Peter) Yau
McGill University

We have developed and implemented a 3D Boussinesq model which incorporates both water in liquid and vapour forms and the effects of latent heating. The Clausius-Clapeyron equation has been approximated in order to yield constant coefficients which let us use them in a Fourier box model. It can therefore integrate in time very much more quickly than it would otherwise be able to. Despite the approximations, first-order accuracy is maintained.

Typically, cloud physicists do not deal with atmospheric turbulence and dynamicists do not deal with latent heating effects. This model is an attempt link these two issues which both play important roles in determining actual atmospheric conditions.

The investigation is being done by dynamicists; as such, we are interested in how classical (dry) stratified turbulence is altered by this new small-scale potential vorticity forcing latent heating heating causes. We are beginning our studies by testing the changes in predictability of stratified turbulence due to the inclusion of moist processes.

3-D-3.3
COBEL Column Model Simulations of West Coast Marine Stratus
Peter Zwack[1], Eva Monteiro[1], Christian Pagé[1], Nathalie Gauthier[1], Robert Tardif[2]
[1]*Université du Québec à Montréal, Département des Sciences de la Terre et de l'atmosphère*
[2]*University of Colorado at Boulder/NCAR*

The US Federal Aviation Agency has been funding UQAM, MIT Lincoln Labs and San Jose State University for a decade long project to better forecast marine stratus dissipation. The column boundary layer COBEL, originally developed by Paul Sabbatier University and Météo France for radiation fog forecasting, was modified to simulate and forecast the evolution of marine stratus. The emphasis of this presentation will be an overview of the COBEL model and what has been learned about the physics of the development and evolution of marine stratus. Finally, we will present a summary of the verification of the COBEL model forecasts for marine stratus dissipation the San Francisco Airport.

3-D-3.4
Boundary Layer Processes and Severe Alberta Thunderstorms
G.S. Strong,
Ardrossan, AB

Alberta thunderstorms form predominantly over the foothills. In this presentation, two seemingly different concepts to explain the formation of severe thunderstorms are shown to be mutually supportive. The author's multi-scale conceptual model of Alberta thunderstorms, involving the creation and subsequent breakdown of a *capping lid*, is shown to be compatible with the dryline explanation for such storms. The dryline storm is simply a special case for the multi-scale model involving the *capping lid*. The capping lid refers to a stable layer capping a moist atmospheric boundary layer (ABL) that is typically 500-1000 m deep during Alberta summer convective situations. A diagnosis of the capping lid requires sequential radiosonde sounding data over the foothills, while *drylines*, which are likened to a 'summer *Chinook*', can sometimes be diagnosed using only surface data. However, an adequate diagnostic study of either phenomenon requires 4-D analyses using sounding data, which unfortunately do not exist operationally, except for special studies such as LIMEX-85.

This presentation will suggest some revisions that combine these two concepts into an expanded multi-scale conceptual model, provide some preliminary analyses, and describe some field tests planned for 2003-04 designed to test the revised model. The use of precipitable water estimates from the University of Calgary GPS receiver network, augmented by data from several radiosonde systems, will provide essential analyses for these relatively modest field tests. The physical processes that first, create the capping lid over a broad area over the foothills east of the mountains, and then break down the lid just before storm initiation, typically all occur within a 4-8 hour period from late-morning to early-afternoon. The whole *capping lid* cycle therefore usually occurs between the operational sounding and synoptic analysis times at 1200 and 2400 UTC. Added to the fact that the only Alberta sounding site is at Stony Plain near Edmonton, not generally representative of ABL processes over the distant foothills, and it is evident that the capping lid is almost never adequately sampled by operational soundings. The GPS receiver network, covering part of the foothills, has the potential to provide continuous output of precipitable water, providing indirect measures of changes in storm intensity parameters such as CAPE, and from which one can infer critical ABL changes taking place prior to storm initiation.

3-D-3.5
Decoupling of the Strongly Stable Atmospheric Boundary Layer over an Antarctic Ice Shelf
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During clear, calm periods throughout the Antarctic winter, decoupling of the boundary layer from the surface is observed. Such decoupling events may be significant for understanding aspects of atmospheric dry deposition and for the interpretation of concentrations of chemical species found in Antarctic ice. This is especially important as Antarctic data are increasingly being used as monitors of global change.

Case studies of decoupling events using surface layer temperature, wind speed, turbulence and sodar data from the STABLE II experiment at Halley, Western Antarctica, will be presented. The implied divergence in heat flux is explained using the turbulence mechanism first proposed by Posmentier (1977) to explain oceanic fine-structure. The most uncertain factor in this hypothesis is the dynamic relation between turbulence transport of heat and momentum. Widely-used 1st order turbulence closure model functions are compared with the STABLE II turbulence data and their departures from observation characterized.

Session 3-D-3

Boundary Layer 2 : Simulation and Observation / Couche limite 2 : simulation et observation

Chair / Président : Peter Bartello

Wednesday 4 June 2003

mercredi 4 juin 2003

Room / Salle Chaudière

3-D-3.6

ELBOW 2001: The Detection of Lake Breeze Fronts Using A Variety of Observational Platforms

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A variety of observational platforms were used to detect low-level boundaries, including lake breeze fronts, in southwestern Ontario during the 2001 field phase of the Effects of Lake Breezes On Weather (ELBOW) project. These platforms included Doppler radar, weather satellite, and surface mesonet. The existence and behaviour of lake breeze fronts for each day during the project period was determined using the resulting dataset. The meteorological conditions under which low-level boundaries could be detected varied for each platform, and considerably more lake breeze fronts were positively identified when observations from more than one platform were used. This has implications for both operational nowcasting and boundary-related research.

3-D-3.7

A Comparative Case Study of Lake Breeze Convective Precursors during ELBOW 2001

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During the summer of 2001, ELBOW 2001, a field study to examine the role of lake breezes on weather was performed in southern Ontario near Lake Huron and Lake Erie. We used satellite, radar, mesonet tower, aircraft and radiosonde data to perform a multi-faceted analysis of the convective conditions throughout the area. Here we examine two case study days, July 18 and July 19 to investigate the sensitivity of convection to the lake breeze and synoptic wind interactions. Previous studies concentrated on interactions either entirely collinear or perpendicular, concluding that the lake breeze circulation, and any subsequent convection, is enhanced when the two are directly opposite. Here we look at two days where in some regions of the study area they are collinear, and in others they are oblique. By oblique we mean that the lake breeze deviates from the synoptic wind by only 45 ° or less. On these two days, the synoptic conditions were similar except for a 45 ° difference in wind direction. The interactions along the Huron boundary on July 19 enhanced convection through gust front and lake breeze interactions, resulting in far greater storm activity than on July 18, where the synoptic wind did not enhance the Huron boundary near any storm gust fronts. We also observed the influence of the shoreline orientation with respect to both the lake breeze and the synoptic wind on convection. In particular, the Erie shoreline created a lens effect that enhanced convection, initiating storms on both days over the same location. Our observations show a greater sensitivity to the synoptic conditions than has been previously described. We also observed that lake breezes and gust fronts tended to merge and collide, and not pass through each other, implying greater complexity than density current studies have shown in the past.

Session 3-D-4

Arctic Oceanography and Meteorology 2 / Océanographie et météorologie arctique 2

Chair / Président : David Barber

Wednesday 4 June 2003

mercredi 4 juin 2003

Room / Salle Pinnacle

3-D-4.1
MSC's Action-Plan 2000 (AP2000) Meeting Canada's Global Climate Observing Requirements North of 60
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To have adequate global coverage, the goal of the Global Climate Observing System (GCOS) is to have one monitoring station in each 5º-latitude by 5º-longitude grid-box for the world. The Canadian GCOS Surface Network (GSN) data set as it existed in 2000, focused primarily on temperature and precipitation. This data set needed to be expanded to provide more comprehensive information (e. g., radiation, snow cover, etc.) required to effectively document and understand climatic processes and predict climate change. In 2000, Canada had 72 climate stations designated as their GSN commitment. This did not meet the GCOS spatial coverage requirement: 19 out of the 45 grid-boxes north of 60ºN latitude had no GSN stations, with 6 of them having no existing climate stations (the other 13 have existing non-GSN climate stations). Lack of monitoring stations in the North was particularly acute and hampering our ability to understand environmental change and provide quality data for NWP. To rectify this situation the Government of Canada committed to Action Plan 2000 (AP2000), which would finance the installation of 45 GSN sites across Canada's North. Installation of 45 GSN stations across Canada's high latitudes (North of 60) was begun in early 2002. The first 15 installations are complete, with a further 13 installations planned for this year and the final 17 scheduled for installation in 2004/05. This presentation will review; the implementation schedule, installation challenges, data standards (reference to data remediation), and the instrument array.

The CMOS conference is the perfect venue for MSC's Atmospheric Monitoring Water Survey Directorate (AMWSD) to update the forecast, science and modeling community on the state of our network in Canada's north.

3-D-4.2
Evaluation of the Direct and Indirect Radiative Effect of Aerosols over the Western Arctic
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Département des sciences de la Terre et de l'atmosphère, UQAM

Arctic climate change due to greenhouse gases and anthropogenic aerosol emissions is a challenge for scientists to investigate due to various complex feedbacks occurring in polar regions.

According to the IPCC, the Arctic climate would be the most affected by greenhouse warming even when sulphate cooling effect is accounted for. However, the predicted warming over the Arctic Ocean is not observed yet in large parts of the Arctic, particularly over the western Arctic during the cold season. Therefore, it appears that general circulation models are still unable to properly represent all feedbacks and physical processes that are likely to be important in the Arctic. This research addresses an important aspect of the arctic climate that is not understood. It is the interaction of aerosols (sulphate, soot, organics, sea salt, dust) with clouds and solar radiation, and their effect on the surface radiative budget of the Arctic. Numerical simulations with the Northern aerosol regional climate model (NARCM) are performed to understand and quantify the direct and indirect radiative effects of these aerosol species on the Arctic climate. NARCM is a regional climate model that simulates prognostically the aerosol size distribution of the 5 aerosol species mentioned above. Observations are used to validate our simulations and identify the drawbacks of our current climate model. The Arctic Regional Climate Model Intercomparison Project (ARCMIP) has offered us an excellent opportunity to validate and inter-compare parameterizations of sea ice, radiation, clouds and surface processes. The enhanced observation datasets such as the Surface Heat Budget of the Arctic Ocean (SHEBA) and the Atmospheric Radiation Measurement (ARM) can be directly compared to our model simulations from October 1997 to October 1998. Our results show that the direct and indirect radiative effects of aerosols are important over the Arctic. It is shown that neglecting strong

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shortwave radiation absorbers such as black carbon aerosols can lead to a substantial underestimation of the surface temperature.

When sulphate, black carbon, organics, sea salt and dust aerosols are considered, NARCM is capable of reproducing realistically the mean surface temperature and its variability observed during the SHEBA field experiment.

3-D-4.3
NCEP/NCAR Reanalysis Surface U and V Field Sensitivity to Northern Hemisphere Annular Modes in The Circum-Polar Region
David E. Atkinson and Steven M. Solomon
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Over the last decade several "reanalysis" data sets have appeared and are making their impact felt in a wide range of climate research activities. One of the most prominent is that produced by the US National Center for Environmental Prediction (NCEP) and National Center for Atmospheric Research (NCAR), the NCEP/NCAR Reanalysis project. Given that the NCEP/NCAR reanalysis employs a forecast model "frozen" in a mid 1990s manifestation in its Climate Data Assimilation System, and given the limited success with which atmospheric models up to and including this period were able to capture major modes of atmospheric variability, it was of interest to determine how these modes are or are not reflected in NCEP/NCAR data for the climatically sensitive circum-polar region.

Surface u and v fields from the NCEP/NCAR reanalysis 6 hourly data set were compared with hourly wind data from 124 coastal weather stations in Russia, Norway, Greenland, Canada and Alaska, and a further 59 stations from the Canadian interior, over the period 1950 - 2000. Vector and Pearson correlations were performed for direction and speed components, respectively, between each weather station and the nearest reanalysis grid point. These correlations were performed for various temporal periods, including annual, calendar seasons, and an arbitrarily defined "open water" and "freeze up" season, and for several speed categories, including "all speeds", "low speed" (station speed <10 m/s), and "high speed" (station speed = 10m/s). For each temporal period and speed category a single mean correlation was determined, by year, for the circum-polar region. These values were compared with standard indices of the major modes of atmospheric variability, the Arctic Oscillation and the North Atlantic Oscillation. Analyses of the comparative time series indicated discernible sensitivity to the Arctic Oscillation, both in trend and in pattern, for various temporal periods in the "high speed" category, more so than for the "low speed" or "all speeds" categories. For the high-speed annual period a relationship for both direction and speed components is apparent. High-speed spring showed strong correlation, especially for wind direction. In many cases there appeared to be an inverse relationship in the first part of the record, i. e., up to ~1965; high-speed summer is an example of this. Reflection of these modes in the correlation time series indicates that the success of the reanalysis data in recreating the observational record is dependent on the modes, and suggests that the model in the CDAS system is not completely capturing these modes of atmospheric variability.

3-D-4.4
Dynamical Feedback Associated To Aerosol Radiative Forcing in the Arctic during Winter
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The Arctic is a very sensitive region to climate change and one of the most difficult to simulate properly. The implication of the climate feedbacks in this region is likely to be important for midlatitude circulation and highly relevant to the Canadian climate change issue. The Arctic winter atmosphere is mainly a balance between infrared cooling and heath transport.

A regional climate model, NARCM (Northern Aerosol Regional Climate Model),is used to investigate the mid-latitude circulation modification resulting from the dehydration-greenhouse

feedback in the Arctic (Blanchet and Girard, 1994). This feedback process is related to the interaction between anthropogenic sulphuric acid aerosols and clouds and it has been hypothesized to occur in the Arctic during the cold season. The resulting effect of this feedback is to increase the dehydration of the lower Arctic troposphere during the cold season. This process produces a strong positive feedback between low troposphere dehydration and IR radiation due to the reduction of the water vapour greenhouse effect and surface cooling (Girard and Blanchet, 2001). To investigate the effect of the dehydration-greenhouse feedback on the Arctic energy budget and midlatitude storm activities during winter, simulations with NARCM are performed. Energy cycle analyses of an important storm occurring in the barocline zone of the Atlantic North will be presented.

3-D-4.5

Implementation and Validation of a New 2-Moment Microphysics Scheme into the Single-Column Model of the Northern Aerosol Regional Climate Model

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Observations have shown that mixed-phase clouds are very common in the Arctic whatever the season. The occurrence of all liquid or all solid clouds is much smaller compared to mixed-phase clouds. Most of existing cloud microphysics schemes have been designed to simulate mid-latitude clouds, under conditions that are not typical of the Arctic. In this research, we present a new microphysics scheme that has been designed to simulate typical arctic clouds such as mixed-phase boundary layer clouds, diamond dust and ice fog forming in stable and well mixed boundary layer. Prognostic variables are the mass mixing ratio and number concentration of cloud water droplets and ice crystals, rain, and snow.

The saturation ratio is free to evolve above 100%. A parameterization has been developed to account for the evolution of the saturation ratio within a climate model time step. The following microphysical processes are represented: the activation of aerosols as CCN/ICN, the aggregation/coalescence, the deposition/condensation of water vapour onto ice crystals/water droplets, the gravitational deposition of ice crystals/water droplets, the autoconversion of ice crystals to snow and of cloud droplets to rain, the evaporation of rain and melting snow and the melting/freezing of snow/rain and cloud ice/water. An explicit size-segregated representation of aerosol distribution is employed, with the alternative of adapting it to the climate models that consider only the bulk of aerosol mass. The new scheme is used to simulate 4 cold seasons (1991 to 1994) at Alert using aerosol observations. It is shown that the new microphyscics scheme is able to reproduce fairly well what the former scheme was simulating. The former scheme was specifically designed to simulate clear sky precipitation and ice fog. A simulation of a mixed-phase case observed during SHEBA is also shown. In the latter case, the microphysics scheme was used in ARCSyM, a regional climate model that considers only the bulk of aerosol mass.

3-D-4.6

A 6 Year Meteorological Record From A High Arctic Glacier: Implications For Mass Balance

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This study analyses a 6-year record (1996-2002) from three automatic weather stations (AWS) located on John Evans Glacier (JEG), Ellesmere Island, Nunavut, Canada. It examines parameters pertinent to modelling the mass balance (MB) of glaciers in the Canadian high Arctic: air temperature, wind speed, and surface elevation change, and assesses the nature and magnitude of the inter-annual variability of these parameters over the six-year period. Seasonal synoptic conditions are also used to determine the relation between variability in MB parameters and general atmospheric conditions.

The AWS are situated at three different locations with respect to the long-term equilibrium line of the glacier. The majority of accumulation at the lower weather station (LWS - 261 m a. s. l.) occurs in the fall (SON), while the majority of accumulation at the upper and middle weather stations (UWS - 1183

m a. s. l.; MWS - 824 m a. s. l.) is in the spring (AM). Winter wind redistribution events have a significant impact on accumulation, especially at the UWS, where they can remove up to 3225 mm of snow in a season. Winter winds result in an atypical gradient of accumulation with elevation: snow depth often declines - rather than increases - with elevation. As expected, the melt season is generally longest and most intense at the LWS and shortest at the UWS, but the MWS does not always fall along this gradient.

Both temperature and wind speed increased from 1996 to 1998-1999, but have decreased in subsequent years. The length of the melt season has increased, with August and September temperatures increasing at all stations over the period of record, and the first fall snowfall to end the melt season occurring later in August, or even in early September. Winter accumulation has decreased from 1996-2000, but shows a slight increase in recent years. Summer melt shows the opposite trend, increasing from 1996-2000, and decreasing since.

500mb synoptic maps indicate that years with significant lowering exhibit a strong high over the archipelago, and weak pressure gradients. Years with reduced lowering are associated with the failed development of the high over the archipelago, and increased pressure gradients associated with the extension from the polar low of a trough southeast into Baffin Bay.

Of the six years of record, four have experienced negative MB. Field data indicate that MB models relying on the assumptions of increasing snow depth and decreasing temperature with elevation are likely to be in error; these issues must be resolved before such models can accurately determine MB trends.

3-D-4.7
Régionalisation de l'Arctique par rapport à la dynamique du climat
J. Litynski

Les changements climatique dans l'Arctique ne sont pas homogènes. En analysant la température de 69 stations terrestres situées au nord du 60-e parallèle pour quatre périodes climatiques : 1931-1960, 1941-1970, 1961-1990 et 1971-2000, on peut distinguer trois régions très distincts. Comme indices chiffrés nous prenons $\Delta T1 = T_{(1961-1990)} - T_{(1931-1960)}$ et $\Delta T2 = T_{(1971-2000)} - T_{(1941-1960)}$. La partie est de l'Arctique canadienne, le Groenland (sauf la partie nord-est) et les îles de l'Atlantique arctique accusent un refroidissement très marqué : $\Delta T1 = -0,75\ ^oC$, $\Delta T2 = -0,54\ ^oC$ en moyenne. Deuxième région qui s'est refroidie est la Sibérie du nord et du nord-ouest : $\Delta T1 = -0,74\ ^oC$, $\Delta T2 = -0,25^oC$ en moyenne. La seule région qui accuse le réchauffement est la partie ouest de l'Arctique canadienne est l'Alaska : $\Delta T1 = +0,32^oC$, $\Delta T2 = +0,38^oC$ en moyenne.

Si on compare $\Delta T1$ et $\Delta T2$ on voit que le rythme de refroidissement des deux premières régions a diminué surtout pour la Sibérie, mais il reste toujours significatifs au niveau 0,95 du test de Student. La région ouest de l'Arctique canadienne et l'Alaska continue à se réchauffer a un rythme qui est presque stable.

Dans le reste de l'Arctique on observe le changements de la température statistiquement non significatifs.

Session 3-D-5

Geophysical Fluid Dynamics / Dynamique des fluides géophysiques

Chair / Président : Peter Taylor

Wednesday 4 June 2003

mercredi 4 juin 2003

Room / Salle Richelieu

3-D-5.1
Moist Component Potential Vorticity
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The importance of water in its solid, liquid and vapour forms to atmospheric thermodynamics is unquestionable. The absorption or release of latent heat during phase transitions is of paramount importance in atmospheric energetics. The links between atmospheric water and dynamics are somewhat more tenuous and not readily understood. However, this key ingredient of the atmosphere serves as a link between thermodynamics and fluid dynamics through the moist component potential vorticity.
A piecewise decomposition of Ertel’ s potential vorticity (PV), coupled with a suitable balance condition, permits a diagnosis of the contribution of atmospheric water to the overall PV field. This allows identifiable features in the total PV field to be coupled with their related moist component PV, thus specifying not only the dry dynamics associated with the system, but also the atmospheric water field directly attributable to the circulation. Moist component PV can be employed both in a diagnostic sense and as an ingredient for piecewise PV inversion. An inversion of the moist component PV field associated with an identifiable PV feature allows for a dynamically consistent, balanced view of the influence of atmospheric water on the system and its surroundings.
PV-based modification of the initial conditions of a numerical model has proven to be an effective method of sensitivity testing and of introducing perturbations for ensemble forecasting. Moist component PV allows for dynamically consistent, balanced modifications to the atmospheric water field, thus supplying an extra degree of freedom to the perturbation set. Especially for research involving moisture-laden systems such as tropical and oceanic cyclones, the ability to consistently perturb or correct the atmospheric water field without introducing imbalances is extremely valuable.

3-D-5.2
Energetics of a Symmetric Circulation with Momentum Constraints
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A theory of available potential energy (APE) for symmetric circulations which includes momentum constraints is presented. The theory is a generalization of the classical theory of APE, which includes only thermal constraints on the circulation.

Accounting for momentum constraints is important in various contexts, including the middle atmosphere circulation and symmetric mesoscale circulations such as hurricanes and fronts. The classical theory of APE applied in such a context may significantly overestimate the energy available for conversion to kinetic energy.

The theory is fully general and can apply to a variety of systems. As an illustration, we apply it to the case of the f-plane Boussinesq equations. It is shown that by including momentum constraints, the APE of a symmetrically stable flow is zero, while the energetics of a mechanically driven symmetric circulation properly reflect its causality.

3-D-5.3
Dynamical Sensitivity of an Eastern North Pacific Cyclone to Downstream Development
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The importance of an upstream influence on the development of an eastern North Pacific cyclone is evaluated by two complementary methods. First, diagnostics of eddy kinetic energy and wave activity are compared. In terms of local group velocity, only minor differences are found during much of the initial evolution. Both diagnostics depict an evolving wave packet that propagates across the North

Pacific Ocean. It is only once the tropopause undulations lose their wave--like appearance that the group velocity calculated using eddy energy becomes different from that depicted by wave activity. Second, by employing numerical simulations of this case, the importance of an upstream trough/ridge couplet, initially over Siberia, is quantified. Various initial conditions are produced using potential vorticity inversion. Simulations in which the Siberian wave are removed from the initial conditions result in both the absence of a downstream developing wavetrain and a weakening of the eastern surface cyclone. Quantification of this weakening will be presented.

3-D-5.4

Zonal Flow Impacting an Isolated Island in the Equatorial Pacific

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Interactions between flows and islands are thought to be significant to the global budget of mixing in the ocean interior. We examine the effects of Jarvis Island (O^o 22.5' S, 159^o 58.4' W) on the equatorial current system. The isolation of this island makes it an interesting case study as any spatial variability in the dynamics near the island are likely attributable to the island itself. CTD casts are coupled with ADCP data in examining the Equatorial Undercurrent (EUC) as it passes the island. Results suggest that the flow around the island is non-linear. A stagnation point in the flow appears several island radii upstream of Jarvis. In the lee of the island, EUC waters are sparse, suggesting boundary layer separation effects.

A set of shallow CTDs on the west side of Jarvis suggest that there is an upwelling of deep water on the west face of the island. At the time of sampling, it appears that the upwelled water is either advected offshore or travels along the south side of the island.

3-D-5.5

The Theoretical Relationship between Double Kelvin Waves and Continental Shelf Waves And Suggestions of DKW Generation over the Labrador Shelf

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We consider the wave modes that are commonly referred to as the Double Kelvin Wave (DKW) and the first mode Continental Shelf Wave (CSW) for the idealized case of a single step change in water depth between the shelf and the deep ocean. A primary goal is to better understand the connections between studies of the DKW with and without coasts and with a rigid lid or a free surface. We find that all previous results can be placed in a common framework by examining the influence of a free surface and coastal boundaries on the cross-shelf length scales, and hence the wave frequencies and phase speeds of the eigenmodes. The first mode CSW can be interpreted as the DKW under the influence of a coastal boundary, or, alternatively, the latter is the shortwave limit of the former. This conclusion is consistent with the results of previous studies, which we complement with a unifying framework and a detailed examination of the transition from the DKW to the CSW as the wavenumber decreases.

The possible generation of DKWs along the Labrador shelf break is also examined. Numerical solutions for the diurnal tide are obtained with open boundary conditions determined by the requirement for consistency with observations. Singular value decomposition is then used to identify the dominant modes of variability in the numerical solution. One of these modes clearly reveals small eddies (about 50 km in radius) that compare favourably with the theoretical DKW solution. We suggest that these eddy-like features are manifestations of DKWs excited by the propagating basin-scale tides as they interact with the local topography.

3-D-5.6
Simple Frontal Models of Baroclinic Instability
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A class of layered mesoscale models is presented, relevant for oceanographic studies of baroclinic frontal instabilities and propagation of coherent structures. The models allow for finite thickness variations in the frontal layer and continuous stratification in the ambient layer(s). The governing equations are derived in a formal asymptotic reduction of the primitive equations, assuming subinertial dynamics and leading-order geostrophy.
The resulting systems are not quasigeostrophic (QG), however, since they allow for vanishing thickness of the frontal layer.

The linear stability problem is solved for idealized and realistic steady basic states, in the presence of linearly sloping topography. Linear stability criteria suggest that introduction of ambient stratification reduces the size of the stable region of parameter space. Indeed, perturbation growth rates associated with the linearized equations are shown to increase with the stratification number, in agreement with previous laboratory experiments. For monotonic frontal profiles, the bottom topography tends to be a stabilizing influence when the interfacial and bottom slopes are of the same sign. This trend is consistent with traditional QG stability results, however, the present models are better suited than QG theory to the description of true fronts, which intersect the topography or fluid surface. Dependence of the instability characteristics on the width and relative thickness of the associated current is also investigated.

Oceanographic and experimental applications of the frontal models are discussed, with particular emphasis on instability of the Denmark Strait Overflow and laboratory investigations of axisymmetric buoyancy fronts. Long-term numerical integration of the models demonstrates plume formation and ejection of coherent vortex features, in agreement with similar primitive-equation studies of coastal processes. In contrast with some previous studies, however, irregularities in the coastline or topography are not necessary for the onset of instability. The present analysis is aimed at capturing the low-order physics of specific types of mesoscale phenomena. While a number of authors have previously explored near-geostrophic balances in the single-layer context, the focus here is to investigate properties of multi-layer models and their applicability to actual oceanographic settings.

3-D-5.7
Kalman Filter Data Assimilation and Balanced Dynamics
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Though the large-scale atmosphere prefers states where the motion is predominantly vertical (so-called near-balance), nsertion of observations into forecast models can excite unrealistic inertia-gravity waves, which in turn contaminate forecasts. Historically, spurious fast oscillations have been controlled by initializing the model on a hypothetical manifold of slow motion. In recent years, four-dimensional data assimilation methods have been designed, which calculate the most probably time-dependent atmospheric state, given the governing dynamics, and a nearly-continuous influx of observations in time. However, since the dynamics admit fast solutions, and because both observations and models have errors, the assimilation schemes do not necessarily return a balanced state.

We examine the question of how well four-dimensional assimilation can reflect the dynamical balance found in nature, by applying the Extended Kalman Filter (EKF) to a modification of the Lorenz 1986 model, which has chaotic slow dynamics and fast waves, and is yet a low-order model. Separation of the fast and slow dynamics holds to good approximation in this model, for sufficiently small Rossby

number. The EKF forces the model intermittently, using observations of variables that have components on both time scales, and does not necessarily respect the separation of the nonlinear fast and slow dynamics. Consequently, the assimilation scheme can generate spurious inertia-gravity waves in the model, even though the true state remains balanced, depending on the crudeness of the assimilation errors. We investigate the possibility and ramifications of modifying the scheme so as to explicitly enforce dynamical balance within the assimilation algorithm.

3-D-5.8
The Impact of Diabatic Heating Structures and Model Resolution on Balanced-State Adjustments and Numerical Model Spin-Up in an Idealized Numerical Simulation
Annie Duhamel
UQAM

Numerical models spin-up is an important source of short-term quantitative precipitation forecast errors. In order to reduce spin-up time and amplitude, numerical models initial dynamic conditions must be modified such that they are consistent with model dynamics equations, with no high-frequency waves, e. g. in a dynamical balanced-state.

It is therefore important to understand how numerical models adjust to a balanced-state when precipitation (and therefore, diabatic heating) is introduced in the initial state of the model simulation. An idealized simulation has been designed for this purpose using the CRCM (Canadian Regional Climate Model) fully compressible dynamical core. This idealized initial state is hydrostatic has null 3D winds, uniform surface pressure, no topography and standard atmosphere temperature vertical distribution (homogeneous in the horizontal).

Balanced-state adjustments have been explored for different model horizontal resolutions and diabatic heating structures. A crude method to modify the initial state of the model (vertical motion, ageostrophic winds, pressure tendency), so that it is dynamically balanced, has also been developed to demonstrate the impact on spin-up time and amplitude of a balanced vs a non-balanced analysis.

4-D-5.9
Internal Wave Excitation by Thunderstorm Outflows
Morris Flynn,
University of Alberta

Abstract: The importance of convection in the generation of atmospheric internal gravity waves (IGW) is well established. Beres, Alexander & Holton (2002) identified three principal mechanisms by which the action of convective elements may excite IGW: the ``mechanical oscillator effect'' which involves the oscillatory deflection to the boundary of a stratified layer by updrafts and downdrafts, the ``obstacle effect'', in which a horizontal mean flow is perturbed by a ``fluidic'' barrier, and the ``deep heating effect'', which is related to the thermal forcing associated with latent heat release within a convective storm. In the present experimental study, we propose a fourth, indirect mechanism wherein IGW are generated by the outflow from a convective storm that propagates as a fluid intrusion along the tropopause.

Experiments are performed in which a fluid intrusion is released along the interface between a uniformly stratified fluid and a uniform fluid. The strength of stratification, the density difference across the interface as well as that between the fluid intrusion and the uniform fluid are varied. IGW characteristics, including their amplitudes, are determined using ``synthetic schlieren.'' IGW are noted in all but the most weakly stratified cases. Their amplitude increases with the intrusion's depth of penetration into the stratified layer. The characteristic angle of IGW propagation is nearly constant however, with values between 42 - 51 degrees. The intrusion's velocity and depth of penetration into the upper and lower layers are well predicted by the theory of Holyer and Huppert (1980) over a limited range of densities. Since this theory assumes both layers to be uniform, we conclude that the behaviour of the fluid intrusion is in certain cases independent of the strength of stratification.

Session 4-A

Plenary/Plenière

Chair / Président : Paris Vachon

Thursday 4 June 2003

jeudi 4 juin 2003

Room / Salle Ballroom B & C

4-A-1

Space Technologies, Global Monitoring of the Natural Environment Canada's Role

Bjarni Tryggvason
Canadian Astronaut Program

Few people have had the privilege to view the Earth from the vantage point of space. Those that have typically speak of the beauty of our planet and try to share this with others through slides and narration. It is challenging to share the unique experience of space flight. The photographs do not capture what the eye does, and words can not create in others the experience of space flight.

From space the view of the Earth is truly breathtaking. The deep blue of the oceans, the pure white of the clouds standing in three dimensions over the surface, the layers of blue stacked through the atmosphere as it is viewed against the blackness of space, the spectacular sunsets and sunrises. Natural processes such as erosion, volcanoes and the seasonal effects are clearly seen. The impact of mankind is also clearly visible. Borders between countries stand out from differences in agricultural practices. Siltation generated by deforestation colors shorelines. The conflict between satisfying energy needs and the pressures from high population densities literally blanket much of the world in a brown haze. Much of the Earth's surface is hidden from the space traveler's view.

Countries such as Canada, the USA and Europe are in the fortunate position of having relatively stable populations and the technologies that provide relatively clean energy sources and effective agricultural practices, making North America, Europe and Australia the cleanest parts of the Earth. The challenges that the Earth faces from the combination of population pressures and the lag in the spread of technology will cross all borders. The wealthy countries, Canada included, will have to take up the major portion of the responsibility for helping developing countries through the transitions and challenges that lie ahead. A far more thorough understanding of the Earth's systems: the oceans, the atmosphere, the biosphere, its changing landmasses, and the impact mankind has on these; will enhance our ability to better resolve the conflicts.

A more thorough understanding will come only as more complete and comprehensive data becomes available to measure and monitor the Earth's systems. Space provides a unique viewing point with the advantage of providing far more complete worldwide coverage and much greater detail in acquisition of data. Over the past several decades Canada has developed technology for interpreting data from remote sensing satellites. It has so far developed only one of the hundreds of major remote sensing satellites that have been or are planned to be placed into orbit.

This presentation will put into perspective the role that space technologies will have in the Earth sciences over the next few decades and will highlight the challenges for Canada's participation.

4-A-2

Water in a Cold Climate: the Mackenzie GEWEX Story

Ming-ko Woo
School of Geography and Geology, McMaster University

A warming trend has been documented over many parts of Canada and this can alter the nature of our water resources, including those of the North. Water, whether frozen as snow and ice or available in support of soil moisture, streamflow, lakes and wetlands, is essential to sustaining the northern environment, people's livelihood and economic development.

The cold region climate-hydrological system is highly complex. The Mackenzie GEWEX (Global Energy and Water Cycle Experiment) Study, with a team of over 60 scientists from the government and universities, is conducting research to understand and model the climate and the water cycle of the Mackenzie Basin. Our studies provide considerable knowledge on the processes by which water and energy flow into and through the Basin. At such high latitudes as the Mackenzie, winters are intensely cold, with prolonged periods of snow accumulation and redistribution by blowing events.

Occasionally, warm air from the Pacific brings in mild spells and enhanced precipitation. In the summer, about half of the rainfall is derived from local moisture sources. Snowmelt is a period with much hydrological activities. Within several weeks, the snow collected over 5-6 months is released to runoff, discharging rapidly to the rivers because of limited infiltration into the extensively frozen ground. The presence of thick river ice cover during breakup inevitably produces ice jams and floods that are a recurrent concern to the river-side communities.

The Mackenzie River integrates the flow patterns of its tributaries from a variety of environments, ranging from the high Cordillera, to the Canadian Shield with myriads of lakes, and the Interior Plains with many wetlands and forests. Every year, the River discharges an average of almost 300 km^3 of freshwater to the Arctic Ocean and this has an important influence on the thermohaline gradient of the polar seas. The streamflow processes within the basin, be they natural or human modified, have strong bearings upon water resource development. An ability to forecast runoff accurately has economical significance, as is exemplified by the need of the Northwest Territories Power Corporation in acquiring timely information to balance the operations of its hydro and thermal power plants. Through collaborative investigations among the scientists and the users, we will provide the scientific basis for policy making. Knowing how water interfaces with the cold climate enables us to address such present and future water issues in the Mackenzie and other northern regions.

4-A-3
President's Prize Winner
TBA

4-B-1.1

The National Radar Project - Update and Status

Paul Joe, Norman Donaldson and Steve Lapczak
Meteorological Service of Canada

The National Radar Project is in its final year of implementation. The project is on time and on budget and by December 2003, there will be thirty-one Doppler radars in the network. The radars are state-of-the-art and provide stable performance and high sensitivity. Ten radars are new and the rest were upgrades to existing radars. The new radars are equipped with 0.65^o beams and the rest have 1.1^o beams. Using Doppler ground clutter filtering and a digital elevation model analysis, negative elevation angles are used on many of the radars in winter to detect snow. The radar processing is done in Regional Centres and at CMC. The latest version of the radar processing software (known as CARDS, the Canadian Radar Decision Support software) focused on developing products and displays for summer severe weather forecasting using a network approach. An update on the project will be presented with particular emphasis on the scan strategy analysis for winter and mountain applications and on how summer severe weather forecasting is done with the new software products and displays.

4-B-1.2

Error Statistics of VPR Corrections in Stratiform Precipitation

Aldo Bellon, GyuWon Lee and Isztar Zawadzki
J. S Marshall Weather Radar Observatory, Dept. of Atmospheric and Oceanic Sciences, McGill University

Errors in surface rainfall estimates caused by ignoring the vertical profile of reflectivity, (VPR), have been assessed by simulating how fine resolution 3-D reflectivity measurements at close ranges are sampled by the radar at various ranges and heights. This approach has the advantage of isolating errors due solely to the VPR while ignoring all other sources of errors that would be present when comparing radar measurements with gauges. Over 200 hours of stratiform precipitation distributed among 21 events and with a distinct melting layer have been used to derive uncorrected and corrected 1-hour accumulations using various procedures. The latter include (a): "local" VPR obtained by a space-time averaging procedure over 30 minutes, (b): intensity dependent "climatological" VPR derived from the entire data set and (c) "event" VPR. The rainfall estimates 0.2 km apart in height up to 5km and 40 km apart in range up to 210 km are compared with the "ground truth" of the original near-range data at the lowest height of 1.1 km. The RMS error structure has thus been derived as a function of height and range and for verification areas ranging from (2x2) km^2 to (14x14) km^2. However, it is the errors at 1.5 km in height up to 90 km and along the height of the lowest elevation angle afterwards that are most relevant since this corresponds to the height of rainfall estimates of the Canadian radars. The stratification of the results in terms of the height of the bright band is essential in order to understand the influence of the bright band with range. The largest errors (100% at near ranges without correction) are encountered with lower bright bands that are both stronger and occurring at heights potentially used for surface estimates. The "local" VPR correction reduces these errors to 30 or 40% at 2 km resolution and by an additional 10% at 10 km resolution. This result is considered as a "best-case" scenario achievable only under conditions of homogeneity of the bright band at all ranges. Surprisingly, the "climatological" and "event" based VPR performed equally well, with errors about 10% higher than those from the "local" VPR.

Session 4-B-1

Remote Sensing 1 : Radar Meteorology and Precipitation / Télédétection 1 : Météorologie radar et précipitation

Chair / Président : Peter Zwack

Thursday 5 June 2003

jeudi 5 juin 2003

Room / Salle Richelieu

Session 4-B-1

Remote Sensing 1 : Radar Meteorology and Precipitation / Télédétection 1 : Météorologie radar et précipitation

Chair / Président : Peter Zwack

Thursday 5 June 2003

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4-B-1.3
Summary of Refractivity Observations by Radar during IHOP_2002
Frederic Fabry
Atmospheric and Oceanic Sciences, McGill University Montreal

During the International H2O Project, near-surface refractivity data were collected by the National Center for Atmospheric Research S-Pol radar in the Oklahoma Panhandle in May and June 2002. Since refractivity is a function of temperature, pressure, and especially moisture, its observations by radar gives us a unique glimpse at the structure of the field of moisture at the mesoscale. There is now increasing interest in such measurements as surface moisture is a key parameter controlling convection initiation and precipitation amounts in summer.

Over the seven weeks of the field experiment, we have witnessed some of the complexity of the spatial distribution of humidity over scales of 1 to 100 km. Many where associated with local circulations driven by uneven soil temperature and wetness, fronts, storm inflows and outflows, and propagating waves such as bores. Many more were boundaries of unknown origin, often without any wind or temperature shifts associated with them. This talk will present an overview of observations with attempts at their interpretation.

4-B-1.4
Errors in the Radar Calibration by Gage, Disdrometer, And Polarimetry: Theoretical Limit and Application to Operational Radar.
GyuWon Lee and Isztar Zawadzki
J. S. Marshall Radar Observatory, Dept. of Atmospheric and Oceanic Sciences
McGill University

Radar calibration is a key source of error in quantitative precipitation estimation and forecasting by radar. Currently, over 100 POSSs (Precipitation Occurrence Sensing System) are deployed all over Canada. They can measure drop size distributions from which R and Z can be derived and types of precipitation. In this presentation, we illustrate potential uses of this instrument in radar calibration and a new self-consistent calibration using radar polarimetry.

A long time record of drop size distributions (DSDs) is used to evaluate the effect of the DSD variability on the accuracy of radar adjustment by comparison with a rain gage on a daily basis. The results show that if a single Z-R relationship is used the relative errors in calibration of the radar as a hydrological instrument is of ~26% on the average with a standard deviation of ~29%. The errors decrease drastically if the appropriate average Z-R relationship for the day is used. A calibration of reflectivity can be done if a disdrometer is available. Good correlations between radar and disdrometric reflectivities indicate that this could be an excellent way of calibrating radar on a daily basis.

The information from operational S-band polarimetric radar is also used to calibrate radar. This method is based on the fact that the specific differential phase shift (K_{DP}) or differential phase shift (φ_{DP}) between the horizontal and vertical polarized beams is immune to the radar calibration error whereas the reflectivity is affected by the calibration error. Due to the variability of DSDs only, the error in polarimetric calibration is 1 dB with a single parameter φ_{DP} and reduces to 0.5 dB when the differential reflectivity (Z_{DR}) is added as well. The stability of this calibration method in time suggests that this method can be used in real time. The sensitivity of this calibration method with respect to the drop deformation is tested. Furthermore, the consistency in the disdrometric and polarimetric calibration suggests that the use of both calibrations allows us to estimate the mean drop deformation.

4-B-1.5

A Radar-Based Methodology for Preparing a Severe Thunderstorm Climatology in Central Alberta

Julian C. Brimelow [1], Gerhard W. Reuter [1], Aldo Bellon [2], and David Hudak [3]
[1] *University of Alberta*
[2] *J. S. Marshall Radar Observatory, McGill University*
[3] *Cloud Physics Research Division, Meteorological Service of Canada*

The RAPID (Radar data Analysis, Processing and Interactive Display) system, developed by McGill University researchers, synthesises spherical coordinate radar data into user-selectable Cartesian maps displaying CAPPI reflectivity, Vertically Integrated Liquid (VIL) water content, and other radar-based parameters. This paper assesses the transferability of the McGill RAPID software to the C-band reflectivity data from the Carvel radar (53.34º N, 114.09º W), and compares observations of severe convection, as identified by selected radar-based reflectivity parameters, against severe weather reports and atmospheric sounding data. The RAPID software was modified to analyse archived Carvel radar observations for July 2000. This period was characterised by exceptional severe convective activity over central Alberta, including seven days with golfball-sized hail, and two days with confirmed tornadoes. The VIL, upper level VIL (UVIL), and the maximum reflectivity at 7 km (Z7) were employed to quantify the strength and frequency of storms within a 120-km radial distance of Carvel. For each day, the intensity of the convection was quantified by counting the total number of 1-km2 pixels in the study area that exceeded the severe thresholds for VIL, UVIL and Z7. The severe thunderstorm algorithms were found to be very effective at correctly identifying the observed severe thunderstorm events. All three radar parameters indicated a diurnal cycle, with severe convection starting after noon and peaking between 1600 and 1800 LDT. A good correlation was evident between the observed storm severity and the daily VIL, UVIL and Z7 pixel counts. The daily UVIL pixel count and Convective Available Potential Energy (CAPE) calculated from proximity soundings were also well correlated.

4-B-1.6

Detection and Monitoring of Precipitation from Space using Spaceborne Passive Microwave Observations

Irene G. Rubinstein
Laboratory for Industrial and Applied Mathematics, York University

Weather radar provide precipitation information for regions close to populated areas. Thus, this information is limited for locations within radar mask. Precipitation information and precipitation type identification are required for areas where no radar installations exist. Remote sensing observations with different instruments capable of rain detection can extend capabilities for monitoring precipitation on regional and global scale. In addition, remote sensing can provide information for validation and calibration of forecast models by providing spatial distribution of precipitation several times per day. Several types of spaceborne instruments have capabilities of detecting precipitation. Advanced Very High Resolution Radiometers on polar orbiting and geostationary satellites provide global observations of cloud top temperatures. Passive microwave sensors because of the multi-frequency observations have capabilities not only to detect precipitation but also provide information about the vertical distribution of hydrometeors within large precipitation cells. In this work we present preliminary results of analysis of winter and summer precipitation events. Time and space collocated SSM/I brightness temperatures , Doppler weather radar (for summer events) and McGill University vertical profiler radar (AIRS IOP s) were compared. Detection of precipitation for the winter case studies was not as reliable as for the extreme summer events. It was encouraging to see that in some cases when there was no precipitation but there were radar returns from above 7 km, 85 GHz channel brightness temperatures indicated scattering processes within the atmospheric layer.

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Chair / Président : Peter Zwack

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4-B-1.7

Comparison Of Precipitable Water Over Canada Obtained From Ground-Based GPS, Radiosondes, and The Canadian Global Analysis System.

Godelieve Deblonde and Stephen Macpherson
Data Assimilation and Satellite Meteorology Division, Meteorological Service of Canada

The presence of atmospheric water vapour causes a delay in radio signals broadcast from satellites of the global positioning system (GPS). Estimates of this delay, measured at ground-based GPS receivers, are used to derive column-integrated water vapour (IWV) for meteorological applications such as data assimilation for numerical weather prediction. The Data Assimilation and Satellite Meteorology Division (DASM) of the Meteorological Service of Canada is collaborating with the Geodetic Survey Division of Natural Resources Canada (NRCan) on a project to evaluate the accuracy and usefulness of ground-based GPS derived IWV. NRCan provided DASM with GPS delay data for 22 GPS sites in Canada for the months of April 2001, July 2001, October 2001 and January 2002. GPS IWV derived from these data are compared with IWV from radiosondes, operational analyses, and trial fields (6-hour forecasts) of the global version of the GEM (Global Environmental Multi-Scale) model. Results of the inter-comparison and the error analysis study will be presented.

4-B-2.1, 2

The Fluxnet-Canada Research Network

H. A. Margolis, A. Barr, J. H. McCaughey, T. A. Black, L. Flanagan, N. Roulet, C. Bourque, P.-Y. Bernier, B. Amiro, W. Chen, R. Grant, J. Chen, S. Wofsy, and C. Coursolle

Human activity has altered the global carbon (C) cycle resulting in a persistent and rapid rise in the level of greenhouse gases in the atmosphere. Canada's vast land area and relatively small population provide us with both a national opportunity and a global responsibility to manage our biosphere for sustainable reductions in greenhouse gases. The Fluxnet-Canada Research Network (FCRN) was formed to address some of the fundamental scientific questions upon which much of Canada's carbon cycle policy is being framed. FCRN is making tower-based eddy covariance measurements of the exchanges of CO_2, sensible heat, and water for mature and disturbed forest and peatland ecosystems along an east-west national transect that encompasses many of Canada's important ecoregions. We examine the relationship between the inter-annual variability of C fluxes and climate; analyze the contribution of different ecosystem components to the net flux; explore the relationship between net primary productivity and net ecosystem production; and parameterize and evaluate ecosystem and land surface climate models. We are also evaluating the relationship between the multi-year measurements of net ecosystem exchange from the towers with multi-year changes in C stocks measured by forest inventory and other biometric techniques. This knowledge, combined with existing land cover data, will provide better first-order approximations of the total potential for C uptake, emission and sequestration by Canadian forests and wetlands on local, regional and national scales.

There are seven Canadian-run flux stations located along an east-west transect for forests in British Columbia, Saskatchewan, Ontario, Quebec and New Brunswick and for peatlands in Alberta and eastern Ontario/western Quebec. At each station, one or more towers in undisturbed ecosystems are combined with at least one satellite tower. The satellite towers study the environmental controls on fluxes from disturbed ecosystems (i. e., following fire, logging, commercial thinning, wetland creation) or different peatland types. Calibration of flux measurements between stations is accomplished by a roving standard set of equipment that will visit all our permanent flux sites at least twice over the study. The different research sites are linked together through (a) a series of network protocols that will assure standardized and/or cross-calibrated measurements of flux, meteorological and ecological variables; (b) standardized data processing protocols; and (c) a standardized policy for the documentation, submission, archiving, and distribution of data that will be managed through a Data Information System. Additional network integration occurs through (a) students and scientists working on research topics that cut across several stations; (b) a cross-station stable isotope component that links the tower-based flux measurements to regional- and global-scale atmospheric measurements; and (c) an integrative modelling effort that optimizes the use of site-based measurements to parameterize the different climate and ecosystem process models that will be used to extrapolate to larger spatial and longer temporal scales. The major funding sources for the Canadian university research are the BIOCAP Canada Foundation, the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS), and the Natural Sciences and Engineering Research Council of Canada (NSERC). Government participants receive support from the Government of Canada Action Plan 2000 on Climate Change, Natural Resources Canada, the Meteorological Service of Canada, and Parks Canada. The FCRN provides Canada with a coordinated ecosystem flux network that can interact with similar networks in other parts of the world.

4-B-2.3

Interannual Variability in the Carbon and Water Balances of a Boreal Aspen Forest in Central Saskatchewan, 1994 to 2002

A. G. Barr[1], T. A. Black[2], K. Morgenstern[2], N. Kljun[2], T. Griffis[3], Z. Nesic[2] & D. Gaumont-Guay[2]
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Session 4-B-2

Canadian Society of Agrometeorology 1 / Société canadienne d'agrométéorologie 1

Chair / Président : Paul Bartlett

Thursday 5 June 2003

jeudi 5 juin 2003

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The Boreal Ecosystem Research and Monitoring Sites (BERMS) program focuses on the carbon, water and energy cycles of the Canadian boreal forest and the role that these cycles play in the global carbon cycle and in climate change. We report eight years (1994, 1996-2002) of measurements of carbon dioxide, water vapour, and sensible heat fluxes at the BERMS Old Aspen site in central Saskatchewan, Canada. Our earlier analysis of 1994 and 1996 to 1998 had reported that annual net ecosystem productivity (NEP) in boreal deciduous forests is controlled largely by spring temperature; warm springs promote early leaf out and increase gross ecosystem photosynthesis (GEP) while having little effect on ecosystem respiration (R). The data from 2001 and 2002 confirm the primary importance of spring temperature but add the new dimension of drought, which was largely absent from the earlier years. The two drought years, with their contrasting warm (2001) and cool (2002) springs, complement the earlier years of 1996 and 1998, which had similar warm (1998) and cool (1996) springs but with near normal precipitation and higher soil moisture. Relative to the non-drought years of 1996 and 1998, the 2001-2002 drought causes a decline in both R and GEP. However, the decline is greater for R than GEP, so that the net drought effect in both years is to increase NEP. The new and significant results from 2001-2 demonstrate the value of long time series in the study of inter-annual variability. We plan to track the continuing impact of the drought into the growing season of 2003 and to follow the transient responses of R and GEP after the drought ends.

4-B-2.4

Measuring Respiration in a Coastal Douglas-fir Chronosequence

E. R. Humphreys, T. A. Black, D. Gaumont-Guay, K. Morgenstern, Z. Nesic[1]

[1]*University of British Columbia, Vancouver*

Timber harvesting and forest regrowth play an important role in Canada's national carbon budget. To assess the nature of CO_2 loss from forests at different stages of stand development, respiration from the forest floor and the forest ecosystem was measured in 3-, 14- and 53-year-old coastal Douglas-fir (Pseudotsuga menziesii var. menziesii (Mirbel) Franco) stands in 2002. CO_2 flux from the forest-floor was measured using a portable soil chamber system on 2 collars at each of 10 locations at each site between May and December. Ecosystem respiration was estimated using tower-based eddy-covariance measurements of CO_2 fluxes at night under turbulent atmospheric conditions. An exponential relationship between CO_2 flux and 5-cm soil temperature was used to derive effective Q10 values, representing the sensitivity of respiration processes to temperature, and R10 values for each stand and for each collar, representing the respiration rates at 10°C. Soil moisture did not have a significant effect on the forest floor CO2 fluxes in any stand ($P < 0.05$). Soil chamber R10 was significantly different between all stands ($P < 0.001$) with the largest value of R10 for the 14-year-old stand, followed by the 53- and the 3-year-old stands at 4.54, 3.43, and 1.88 µmol m^{-2} s^{-1}, respectively. R10 values for the soil collars ($n = 30$) were found to be significantly and positively correlated to total N in the top 0-3 cm of soil. Soil chamber Q10 values of 2.04 and 2.16 were not significantly different between the 3- and 54-year-old stands, respectively, while Q10 of 2.60 for the 14-year-old stand was significantly greater than the other two ($P < 0.05$).

During the 7-month period, the ecosystem respiration rates were largest for the 53-year-old stand followed by the 14- and 3-year-old stands, where R10 was 6.00, 4.10, and 2.43 µmol m^{-2} s^{-1}, respectively. These reflect the increasing importance of respired CO_2 originating from needles, stems, and understory vegetation with increasing stand age. In the 54-year-old stand, the dense canopy of 30 - 35 m tall trees contributed greatly to total ecosystem respiration such that modelled forest floor respiration was only 56% of the total. However, at the 3- and 14-year-old stands, modelled forest floor respiration still accounted for over 90% of the total modelled ecosystem respiration. These results emphasise the importance of incorporating both vegetation and forest floor respiration and controls into landscape-level carbon budget models.

4-B-2.5

Aggregating Surface Properties in the Canadian Boreal Forest

Paul Bartlett[1], Harry McCaughey[2], Peter Lafleur[3], Diana Verseghy[1], Yves Delage[4]
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The limited resolution of regional and global climate models necessitates grid cells that contain a variety of surface types. The use of a mosaic, in which the surface is represented by a number of user-defined patches, offers a compromise in complexity between the traditional single-surface or aggregated approach and the computational expense of increased model resolution. Knowledge of the combinations of surfaces and associated properties that are likely to benefit from the use of a mosaic will maximize the benefits and minimize the computing requirements of the mosaic approach. In this study, the Canadian Land Surface Scheme is employed in off-line mode, over the Canadian boreal forest, to assess some simple methods of aggregating surface properties. The mosaic framework is used as a basis of comparison for the various aggregated model runs. Modelled sensible and latent heat fluxes are found to be more sensitive to the aggregation of soil properties, than to the aggregation of vegetation properties. Aggregating the soil eliminates dry areas that experience moisture stress, and causes the latent heat flux to be overestimated. A modified blending height approach for aggregating surface roughness provides a momentum flux that is in good agreement with the mosaic approach. However, the impact of various approaches to roughness length aggregation on the sensible and latent heat fluxes is small, and there is evidence of edge effects, which are not accounted for.

4-B-2.6

Tropospheric Ozone in the Forests of the Lower Fraser Valley, British Columbia and the Threat of Injury to Forest Plants

Judi Krzyzanowski
Department of Geography, University of British Columbia

During the summers of 2001 and 2002 ambient ozone levels were measured as hourly averages in parts per billion (ppb) at four sites of differing elevation (200, 400, 600 and 1200 m) in the Lower Fraser Valley (LFV), British Columbia. All sites were located in forest clearings and experienced hourly averages as low as 0ppb, and >70ppb. Mean seasonal concentrations show an increase in ambient ozone with elevation due to consistently high nocturnal concentrations and lack of diurnal variation at higher altitudes. Diurnal patterns are in agreement with previous studies showing a peak in concentration in the late afternoon, and a morning increase due to photochemical production and residual layer down mixing. The occurrence of a high pressure ridges cause above average ozone levels to occur, and may cause the National Ambient Air Quality Objective of 82ppb to be exceeded at 1200m. Cumulative ozone exposure was measured with height in a forest canopy using OGAWA passive samplers mounted to a 10.5m tower. A strong power-law increase in ozone with height was found and is thought to be due to both a lack of turbulent down mixing, and dry deposition at the surface. This relationship would effect the intensity ozone exposure experienced by plant species of various heights. A preliminary survey of native shrubs exhibiting visible ozone injury symptoms suggests that current concentrations of tropospheric ozone in the LFV may be high enough to cause injury to forest species.

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Chair / Président : Paul Bartlett

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Session 4-B-3

Mackenzie GEWEX Study / Étude GEWEX Mackenzie

Chair / Président : Murray Mackay

Thursday 5 June 2003

jeudi 5 juin 2003

Room / Salle Pinnacle

4-B-3.1

Trajectories of Atmospheric Moisture for a Heavy Rainfall Event over the Mackenzie River Basin

Julian C. Brimelow [1], Gerhard W. Reuter [1], and Peter Yau [2]
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The annual water budget of the Mackenzie River Basin (MRB) can be significantly affected by a few extreme summertime precipitation events. One such heavy rainfall event occurred between 28-30 July 2001 and produced 60-100 mm of rain (up to 100% of mean July rainfall) over the Athabasca River Basin. Moisture from local sources, while important, was probably insufficient to explain the high rainfall amounts observed during this rainfall event. The objectives of our research were to identify distant sources of low-level moisture for this particular event, and also identify the mechanism/s responsible for transporting the moisture-laden air. The origin of the low-level moisture was determined by computing three-dimensional trajectories using archived NCEP data and the Hybrid Single-Particle Lagrangian Integrated Trajectory model. The trajectory analyses suggest that some of the moist low-level air for the 28-30 July rainfall event originated over the Gulf of Mexico and not from the Pacific or Atlantic Oceans. The moisture transport occurred along either continuous or step-wise trajectories, and was transported from the Gulf of Mexico to the southern MRB in 7 to 10 days. The northward extension of the Great Plains low-level jet (which was significantly stronger than normal) into Saskatchewan, coinciding with strong lee cyclogenesis over central Alberta, played an important role in transporting Gulf of Mexico moisture over the southern MRB. Results from high-resolution MC2 model simulations of this event will also be presented.

4-B-3.2

Radiation Budgets in the Mackenzie River Basin: An Evaluation of the Canadian Regional Climate Model

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The Canadian GEWEX Enhanced Study (CAGES) was a 14-month period in 1998/1999 during which there were enhanced measurements of water vapour, precipitation, snowcover, radiation, snowmelt, evaporation, stream discharge, and other variables in the Mackenzie River Basin (MRB). These measurements provided the initialization and validation fields for modelling and remote sensing studies. During the CAGES period there were only limited broadband satellite observations of radiation fluxes over the MRB from the second flight model of the Scanner for Radiation Budget (ScaRaB) instrument. A more extensive dataset of solar radiation fluxes at the top of the atmosphere (TOA) and at the surface was derived for CAGES from NOAA-AVHRR observations. The derived solar radiation fluxes at the surface were evaluated against the surface measurements in the basin. The results show that mean differences are generally less than 10 W m^{-2} at each site.

Solar fluxes at the TOA and at the surface, and LW fluxes at the TOA from the Canadian Regional Climate Model (CRCM) are compared with those from satellite measurements and retrievals. It is found that the CRCM overestimated the TOA reflected solar flux consistently by an average of 33 W m^{-2} during summer months, while during months when the surface is mainly covered by snow, the CRCM agrees with satellite retrievals well, with a mean difference of 2.1 W m^{-2}. The differences in the basin monthly mean atmospheric absorption between the CRCM and the satellite retrievals for 9 months during the CAGES period vary from -11 to 12 W m^{-2}. The overestimation of the TOA reflected fluxes in the model during the summer months is mainly at the expense of an underestimation of the net surface solar fluxes. A comparison of cloud amount from the CRCM and the satellite retrievals shows an over-prediction by the CRCM, which is responsible for the overestimation of the TOA reflected flux during the summer months. A comparison of outgoing LW flux from the CRCM with satellite measurements in winter months during the CAGES period shows

the CRCM fluxes to be 6 to 12 W m^{-2} less than the measured fluxes, which is at least partly due to the underestimation of surface temperature in the model.

4-B-3.3

An Assessment of Two Land Surface Schemes under Subarctic Tundra Conditions

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Observation and climate modeling studies have shown that the impact of climate change could be greatest at high latitudes where tundra is prevalent. The atmospheric component of a climate model is coupled to a land surface scheme (LSS) to provide the lower boundary condition for the atmosphere. The Interaction Soil-Biosphere-Atmosphere (ISBA) scheme and the Canadian Land Surface Scheme (CLASS) are two LSSs developed respectively at the Météo-France and the Meteorological Service of Canada (MSC). ISBA is coupled to the GEM (Global Environmental Multiscale) model as the operational weather prediction model at the Canadian Meteorological Centre (CMC), and CLASS is the LSS in the Canadian Regional Climate Model. The principal Canadian contribution to the international Global Energy and Water Cycle Experiment (GEWEX) project is through the Mackenzie GEWEX Study (MAGS). The Mackenzie River basin is located in the Canadian subarctic region. Observations from MAGS provide a unique opportunity to test the performance of ISBA and CLASS in high latitude conditions through an evaluation of the soil moisture and the sensible and latent heat fluxes.

We use data collected at two subarctic tundra sites from MAGS located in the Trail Valley Creek (TVC) drainage basin, North West Territories, Canada. The TVC basin is a subbasin of the Mackenzie River basin, and the two sites are located in a cryoturbated region and are underlain by continuous permafrost and feature mineral soil hummocks and organic soil inter-hummock zones. Both ISBA and CLASS were run in a stand-alone mode from July 2 to September 30, 1999, and the results are compared with observations at each site. The surface flux is well simulated by both ISBA and CLASS, with the latent heat flux being slightly underestimated and the sensible heat flux overestimated. A comparison of the soil moisture simulated by ISBA and CLASS with observed values is also made.

4-B-3.4

Snow, Sublimation, Canopies and CLASS

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A comparison of the treatment of snow within two versions of the Canadian Land Surface Scheme (CLASS 2.7 and 3.0) has been made. The incidence of, and sublimation in, blowing snow are compared using a parameterization based on the results obtained with the PIEKTUK model of blowing snow. The treatments in both models of interception of snowfall in the tree canopy, and the sublimation and drip of the intercepted snow are compared. The sensitivity of these schemes to vegetation type and wind speed is discussed. The combined results of the various parameterizations are also compared to snow depth data from weather stations (BOREAS and Goose Bay) in northern and eastern Canada.

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4-B-3.5

Using the Special Sensor Microwave Imager to estimate a soil wetness index for the Mackenzie River Basin

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The aim of this work is to provide a dynamic estimate of a soil wetness index in the Mackenzie River Basin, in North-West Canada. The method used in this study is based on the Basin Wetness Index approach (Basist and al., 2001). This index is based on the brightness temperature remotely sensed by SSM/I in the 19, 37 and 85 GHz channels and the soil surface temperature. In fact, the liquid water reduces the emissivity of the soil surface as a function of these different frequencies. The BWI index was computed on a daily basis for two summer seasons, pixel wise (625 km^2) over the entire surface of the Mackenzie River Basin ($1.8x10^6$ km^2), which roughly comprises 20% of Canada. The BWI estimates reliability was assessed with a combination of approaches including in-situ measurements and hydrological modeling of surface soil-moisture.

In its basic formulation, the BWI uses two empirical parameters that are constant in both time and space. The basin heterogeneity and the temporal evolution of the vegetation state suggest that these parameters could vary. An alternative approach is proposed that allows for a reassessment of the empirical constants at the reception of each new image. This dynamic readjustment of the parameters leads to extract the maximum of information relating brightness temperatures to soil temperature measurements.

4-B-3.6

Using Climate Station and Gridded Data for Modelling Daily Streamflow of a Large Mountainous Catchment

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Mountainous catchments consist of a complexities of landscape, with large ranges in elevation and a variety of surface covers. The application of macro-hydrological models requires a suitable set of parameters and climatic input data that reflect the influence of the rugged terrain. The SLURP (Semi-distributed Land Use based Runoff Processes) model was applied to the Liard basin as a test case to examine the effects of model parameters and data sets on streamflow simulation.

Ten of the SLURP parameters were given specified ranges of values before allowing the model to calibrate for their optimized values for each land cover type. The model was then run for the Liard and 35 of its sub-basins for 1992-99. It was found that (1) the influence of the parameters depends on the extent of their corresponding land covers in a basin; (2) parameters derived for the entire Liard catchment does not perform well when applied to its sub-basins; (3) inaccuracies in estimating the initialization parameters can be overcome when a start-up period is included in the model run; and (4) a better fit to observed streamflow is obtained by using the set of parameters obtained by 'supervised' calibration (e. g. specifying the limiting values) rather than by allowing SLURP to derive all the parameters by 'default'.

Climatic stations in and around the Liard catchment provide in situ data for the model run. SLURP interpolates the temperature and precipitation data for the 35 sub-basins and then adjusts the interpolated values to account for elevation effects. We also made use of the gridded data produced by the Meteorological Service of Canada (herein called Cangrid data) which offer monthly temperature and precipitation fields for the study area at a 50 km resolution. The use of both sets of data yielded good fits for the Liard (Nash-Sutcliffe R-coefficient of 0.84 using in situ data and 0.73 using Cangrid data), both in terms of the timing and the high flow values, though the low flows are over-estimated. Most of the parameter values derived from calibrating the two sets of data are comparable, but large differences occur in the storage and retention coefficients, possibly as a consequence of an attempt by the model to adjust for the disparities between the precipitation interpolated from the two data sets.

This suggests that the climatic input data have notable effects on streamflow simulation for the mountainous environment, thus reinforcing the commonly-held view that these areas need a more extensive station network to gather accurate data.

4-B-3.7

Development and Evaluation of the Distributed Hydrologic Model WATCLASS for the Mackenzie Basin GEWEX Study

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As part of the Mackenzie Basin GEWEX Study (MAGS) our group is developing and testing meso-scale hydrologic models. The objective of MAGS is to understand the water and energy balance for the Mackenzie River Basin. In such a data sparse area, modelling plays an important role by providing a framework for the integration of observations into a consistent description of the balances. The challenges are that the observational database is extremely limited and the processes are poorly understood for northern domains.

The WATCLASS model is a distributed hydrologic model that includes a detailed simulation of the energy and water balances within a watershed. Various recent modifications have been made to WATCLASS including changes to the snow processes and the treatment of soil drainage. The impacts of these changes are presented by examining their effects on the simulated streamflows of various test basins around Canada including: The Grand River basin in southern Ontario, the Wolf Creek basin near Whitehorse, Yukon, and the study basins used in the BOREAS project.

Results of WATCLASS simulations are then presented for the time period 1996-2001 on the Mackenzie basin. The resulting streamflow hydrographs are compared to measured data. As well, internal variables are compared to independent data sources such as output from atmospheric models and satellite imagery.

Also presented are values from WATCLASS for the three major components of the water balance (precipitation, evaporation, and runoff) on a monthly basis for the entire Mackenzie basin and its 5 major sub-basins.

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4-B-4.1, 2
Argo - The Global Profiling Float Array
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Scientists from fifteen nations are collaborating in a project, Argo, to deploy a global ocean climate-monitoring array, and several more are on the point of joining the group of "float-deploying nations". This talk will outline the objectives of the Argo array, will outline Canada's contribution so far, and will present an outlook on the prospects for achieving global coverage in the foreseeable future. The talk will then focus on the data system. Critically, all countries deploying floats have agreed to share the data globally, with no constraints on access in near real-time. Mostly this is working very well and over 95% of the data does actually become available to users within 24 hours. The real-time data has been subjected to automated QC procedures and we are in the process of implementing a delayed mode quality control system. Progress towards achieving that will also be discussed. Finally, in response to some concerns about the data system, some effort has been expended on building systems to ease access to Argo profile data. Potential users will receive a thumbnail sketch on systems available to enable swift and efficient access to the global data set.

4-B-4.3
On-going Applications in Operational Oceanography for the Gulf and Estuary of St. Lawrence
Denis Lefaivre and François J. Saucier
Maurice Lamontagne Institute, Ocean Sciences Direction, Fisheries and Oceans Canada

The Gulf of St. Lawrence is a semi-enclosed northern shelf sea with large river runoff, tides, eddies and internal waves, and a strong seasonal cycle characterized by a nearly complete sea ice cover during three to four months of the year. There are some 7000 commercial ships transiting through the GSL each year and an increasing pressure for more efficient transportation, coastal development, habitat protection, oil and gas exploration, and other economic growth-related aspects. This presentation will demonstrate on-going applications in operational oceanography for the Gulf and Estuary of St. Lawrence. It will be shown that networking among clients and experts from various governmental agencies is a critical aspect of operational services that can readily meet high standards and lead to success stories. For the Gulf of St. Lawrence, the following partners work in collaboration with marine transport industry to produce routine daily forecast products : Canadian Hydrographic Service, Canadian Coast Guard, Meteorological Service of Canada, Canadian Ice Service, Science Branch of Fisheries and Oceans. These products include : storm surges for coastal flooding, sea ice dynamics for vessel routing, surface currents for search and rescue or oil spill trajectories, wind waves, and other value-added products available from unified ice-ocean-atmosphere forecast models. These products are either available on the World Wide Web **www.osl.gc.ca** or through other Internet servers. In addition to the daily assimilation and short term forecast, several products may be issued as a result of maintaining state-of-the-art ice-ocean models along with high-performance computing facilities: Atlas of Tidal Currents, Tide Table, investigations for impact studies, and so forth. The outlook for structuring operational oceanography in Canada will be discussed from the lessons learned from the first ten years of operations in this region.

Opérations en cours en océanographie opérationnelle dans l'estuaire et le golfe du Saint-Laurent

Le golfe du Saint-Laurent est une mer côtière septentrionale presque fermée caractérisée par des apports importants d'eau douce, des marées, des gyres et ondes internes et des variations saisonnières importantes dont une couverture de glace presque complète pendant deux à trois mois chaque année. Il y a de l'ordre de 7000 navires commerciaux qui transitent dans le GSL et on voit des pressions grandissantes pour une navigation plus efficace, du développement côtier, pour la protection des habitats, pour de l'exploration pétrolière et autres aspects reliés au développement économique. Nous présenterons les opérations en cours en océanographie opérationnelle dans l'estuaire et le golfe du

Saint-Laurent. Nous démontrerons que le réseautage entre les clients et les experts des différentes agences gouvernementales est un élément critique des services opérationnels pour permettre d'atteindre des hauts standards scientifiques et mener à des succès. Dans le golfe du Saint-Laurent, les partenaires suivants travaillent en collaboration avec l'industrie du transport maritime pour produire des prévisions quotidiennes opérationnelles : Le Service hydrographique du Canada, La Garde Côtière canadienne, Le Service Météorologique du Canada, Le Service Canadien des Glaces, La Direction des Sciences de Pêches et Océans. Ces prévisions incluent : Les ondes de tempêtes pour les inondations côtières, la dynamique des glaces pour la navigation, les courants de surface pour Recherche et Sauvetage (GC) ou la dérive d'hydrocarbure déversé, les vagues induites par le vent et d'autres produits issus des modèles intégrés de prévision glace-océan-atmosphère. Ces produits sont disponibles par Internet à **www.osl.gc.ca** ou par d'autres serveurs. En plus des assimilations quotidiennes et des prévisions à court terme, plusieurs produits deviennent disponibles comme résultat de la mise en place de modèles glace-océan à la fine pointe des connaissances dans un environnement informatique performant : Atlas des courants de marées, Tables de marées, calculs pour étude d'impact, etc. Nous présenterons une perspective d'avenir pour structurer l'océanographie opérationnelle au Canada tirée de l'expérience des premières dix années d'opération dans cette région.

4-B-4.4

Real-Time Forecasting of Total Water Levels along the East Coast of Canada

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[3] *Bedford Institute of Oceanography, Department of Fisheries and Oceans*

A large-scale storm surge model for eastern Canada (Bobanovic and Thompson, 2003) has been run operationally by Environment Canada for 3 years. The root mean square error of the 1-day surge forecasts are spatially variable but of order 10 cm. The focus of this presentation is forecasting of the sum of the tide and surge components of sea level i. e. the total water level. The tide is predicted in three ways: (i) harmonic analysis of long, hourly sea level records for specific locations, (ii) WebTide, a tidal prediction system based on a barotropic, finite element tidal model of the east coast of Canada that assimilates both coastal and altimetric sea level observations (iii) an extended version of the surge model that includes tidal forcing along its open boundaries. The skill of the forecasts of total level will be quantified using sea level data collected in real-time from a number of east coast Canadian ports. It will also be shown how the combined tide and surge model, coupled with a statistical model of the forecast errors based on the Kalman filter, can be used to quality control observations in real time and, in particular, identify timing errors and datum shifts in the observed sea level record.

Bobanovic and Thompson, 2003. The large scale barotropic response of the SEastern Canadian Sheld Seas to Synoptic Meteorological Forcing. Submitted to *Journal of Geophysical Research* and responding to reviewers' comments.

4-B-4.5

A POM-Based Forecast Ocean Modelling System for the Northeast Pacific

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An operational numerical ocean model capable of providing forecasts of temperature and salinity out to 48 hours is being developed at the Institute of Ocean Sciences (DFO) as part of a Defence Research Development Canada (DRDC) Technology Investment Fund (TIF) funded program. The simulations will enable us to assess the ability of prognostic ocean models to enhance the accuracy of acoustic propagation estimates in the northeast Pacific Ocean. The model is based on the Princeton Ocean Model (POM) and has a 1/8 degree (~12 km) horizontal resolution and 29 vertical sigma levels. Temperature and salinity fields are updated once a week using 1/8 degree analyses provided by the U.

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S. Navy Modular Ocean Data Assimilation System (MODAS). Model forcing includes six major semi-diurnal and diurnal tidal constituents, and atmospheric pressure and winds from the U. S. Navy Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS). The operational system runs daily to provide 6-hourly forecasts of three-dimensional temperature, salinity, and sound velocity out to a maximum of 48 hours. The forecast fields are electronically available to the Department of National Defence as soon as the ocean model forecast is complete.

4-B-4.6
Modelling Tsunami-Generated Currents in Canadian West Coast Harbours.
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High-resolution numerical experiments were performed to estimate ocean currents in local harbours of Victoria and Esquimalt during and after large tsunami events. The hypothetical tsunamis were excited by sea level deformations off the West Coast (42-51N), using several plausible deformation and rupture scenarios for a megathrust Cascadia Subduction Zone earthquake, with a moment magnitude of about 9. The last such earthquake is believed to have occurred in 1700. The characteristics and variability of the tsunami-generated currents are discussed for these two harbours, with implication for local marine traffic and shore facilities.

4-B-4.7
Assimilation of Lagrangian Data Using the Ensemble Kalman Filter: Idealized Experiments Based on an Idealized Vortex System
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It is generally accepted that models of the deep ocean must assimilate observations in order to make realistic forecasts. Satellites are providing a large amount of information on the surface properties of the ocean including its height, temperature, color and roughness. Recently a new observation program, ARGO, has started as part of the Global Ocean Data Assimilation Experiment. ARGO is establishing a global array of 3000 vertically profiling floats that will drift with the currents at 2000 m, rising to the surface every 10 days to transmit the vertical profiles of temperature and salinity, and their horizontal position. In this talk we will explore the extent to which ARGO position data can improve initial conditions for eddy resolving ocean models. We will use the Ensemble Kalman filter to assimilate pseudo position data obtained in a series of identical twin experiments. The dynamical model for the twin experiments is based on (i) nonlinear equations relating drifter position to spatially varying flow fields, (ii) and a stochastically forced equation for the movement of vortex system that includes 4 vortices with a hyperbolic point. We will show that the Ensemble Kalman filter is effective at estimating the true position of the drifters, and the center of the vortex system, from drifter positions observed with error. The use of the Ensemble Kalman filter in the assimilation of real observations into a complex, computationally-demanding ocean models will be discussed and compared with results based on other assimilation techniques including the Extended Kalman filter.

Session 4-C-1

Remote Sensing 2 : Coastal Zones and Oceans / Télédétection 2 : Zones côtières et océans

Chair / Président : Jim Helbig

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4-C-1.1

Integrating SONAR, LiDAR, GPS and CASI on Prince Edward Island: Towards a Seamless Coastal DEM

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In the study area on the North Shore of Prince Edward Island, the coastal zone can be considered to extend from a landward limit of sand dune sedimentation to a seaward limit of storm-induced sand mobilisation. Construction of a seamless digital elevation model (DEM) across this zone is important for the interpretation of coastal geology and geomorphology, detection and measurement of coastal change, storm-surge flood-hazard mapping and as a base for dynamic coastal modelling. Due to the wide range of environments present within the coastal zone, various technologies are required to build a seamless, full coverage DEM.

We use airborne terrestrial LiDAR at low tide to map the landward portion of the coastal zone and various SONAR systems to chart bathymetry of the seaward portion out to depths of 30 m or more. The acoustic methods include swath multibeam systems (EM1000 in 10 m water depth and EM3000 in 4 m depth) and 12-channel sweep or dual-frequency single-beam systems in shallow water. In selected intertidal areas, elevation data are collected using dual-phase differential GPS in real-time kinematic mode. Even with the use of all these systems, bathymetric coverage typically does not extend far enough landward to seamlessly meet the terrestrial LiDAR. Where shallow water sweep or high-density single beam SONAR bathymetric mapping is not conducted, a gap in the DEM extends from the intertidal zone to 10 m water depth.

In this study, we tested the application of hyperspectral CASI data and the Self-Calibrated Spectral Supervised Shallow-water Modeller (4SM) method for filling this nearshore gap. The 4SM method utilises the variable attenuation by water of differing wavelengths of visible light, along with a band-ratioing technique to estimate attenuation coefficients and derive bottom depths from geometrically and radiometrically corrected CASI imagery. Single-beam echosounding data collected and used to fine-tune and validate the derived bathymetry demonstrate excellent accuracy of the CASI bathymetry in some areas and problems with the technique in others where the assumptions of the method are inapplicable. These include constant bottom characteristics and water properties.

The integration of CASI with SONAR, LiDAR and GPS data shows considerable promise for filling the nearshore gap and represents a relatively fast and low-cost method for the development of a seamless coastal DEM.

4-C-1.2

High Frequency Surface Wave Radar Operating in Regions of Shallow Water

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Over the the last three decades significant advances have been made in the application of high frequency surface wave radar (HFSWR) to ocean parameter estimation. In developing these estimation techniques, it has been necessary to explore the underlying scattering mechanisms for HF radiation impinging the ocean surface (see, eg., [1,2,3]). The coupling of the radiation to the gravity waves, which may be modeled as Bragg scattering, is accounted for in all the HFSWR spectral cross sections of the ocean via a so-called coupling coefficient which itself incorporates electromagnetic and hydrodynamic effects. At the decametric wavelengths associated with HF radiation, this coupling coefficient, and hence the Doppler spectra of the scattered energy, depends critically on water depth.

This manifests itself as an increasing higher-order energy in the regions surrounding the large, and essentially stable, first-order peaks in the Doppler spectrum as depth decreases.

Here, the water depth effect referred to above is examined using the models developed in [3]. This is done for a variety of wind speeds and directions as well as for different operating frequencies. It is seen that in some instances the higher-order effects do not differ greatly in magnitude from the first-order. Besides the fact that these models, on inversion, can be used to provide important information on ocean surface phenomena such as winds and waves, they also indicate the possible detrimental effects which decreasing water depth may have on target detection. That is, as the higher order energy increases, targets on the ocean surface falling in these regions of the Doppler spectrum will obviously become more difficult to discern from the clutter. A proper understanding of the depth effects is thus important in seeking ways of mitigating the problem of ocean clutter.

One of the initiatives giving importance to proper modelling of shallow water effects involves the development by Raytheon Canada of an HFSWR in the 10-18 MHz band which is useful for detecting and tracking small targets such as "go-fast" boats and small, low-flying aircraft. At these frequencies, shallow water analysis is relevant when water depths drop below about 5-10 metres. Spectra from a test site in the Caribbean indicate large returns surrounding the Bragg peaks in spectra obtained from a shallow bank where water depths of 2 to 4 metres existed from a range of 40 km to 90 km from the radar. Prior to the bank, water depths of greater that 500 fathoms exist.

Further validation of the importance of incorporating water depth into the scattering models, with a view to enhancing the already considerable utility of HFSWR as a remote sensing tool in the marine environment, is ongoing.

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4-C-1.3
Ocean Environmental Conditions from 3.0-5.0 MHz HFSWR

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High frequency surface wave radar has proven useful for the characterisation of winds, waves, and currents in the coastal zone. Recently, National Defence has investigated the use of 3.0-5.0 MHz HFSWR for the monitoring of ship and air traffic in the Canadian Exclusive Economic Zone. Two HFSWR systems installed at Capes Race and Bonivista, Newfoundland, have been used to show the utility of the systems for traffic monitoring. The systems installed operate with wavelengths an order of magnitude longer than the standard CODAR systems currently used for environmental monitoring. While the long wavelength provides excellent long range propogation for the imaging of vessels; the environmental utility of the signal is reduced.

The 60-100 m wavelength radar systems do provide wave and current data that can be useful in an operational setting. It will, however, be shown that winds are not immediately available from the HFSWR signal. Environmental parameters derived from the HFSWR will be compared with in situ and satellite sources.

4-C-1.4

Comparison of Ocean Gravity Wave Spectra Measured with Surface Wave Buoys, Acoustic Doppler Current Profilers and Space-Based Synthetic Aperture Radar

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The directional energy spectrum of ocean gravity waves is usually measured by floating buoys equipped with accelerometers. Since they are on the sea surface, wave buoys are susceptible to damage by shipping and loss due to mooring failure. Two radically different alternative methods for measuring wave spectra involve the use of acoustic Doppler current profilers (ADCP) and imagery from space-based synthetic aperture radar (SAR).

The ADCP technique, recently developed by RD Instruments (**www.rdinstruments.com**) utilizes the backscatter of high frequency acoustic pulses from the sea surface measured by an ADCP located on or near the seabed. ADCPs can be installed for up to two months with no surface expression making the mooring immune to the passing of surface ships. The time-dependent displacement of the sea surface measured with four acoustic beams provides the information used to calculate the directional wave spectra for frequencies greater than 0.5 Hz. Frequency components lower than 0.5 Hz are measured non-directionally using a pressure sensor in the ADCP.

Standard and wide mode SAR images from RADARSAT-1 were processed to inter-look image cross-spectra using image subscenes centred on the location of a wave buoy. The individual looks correspond to different times in the acquisition process separated by approximately 0.15 seconds. The relative phase shift between the looks is used to resolve the wave propagation direction. The portions of the magnitude of the cross spectrum with positive phase correspond to the normalized directionally resolved SAR image spectrum. Due to the non-linear nature of the SAR imaging process, the spectra tend to be constrained in the along-track direction and are difficult to invert to ocean wave spectra under generalized circumstances.

We present a comparison of ADCP and SAR-derived gravity wave spectra to spectra measured with TriAxys and Endeco wave buoys. Data from all three types of sensors were obtained during sea trials on the Scotian Shelf in October 2000 and June 2002.

4-C-1.5

An Examination of the Physical and Optical Properties of Melt Ponds on Landfast First Year Sea Ice

Robert Kirk and David Barber
Centre for Earth Observation Science, Faculty of Environment, University of Manitoba

Time series physical and optical characteristics for a melt surface were collected during the Collaborative-Interdisciplinary Cryosphere Experiment 2002, over a 3km x 3km smooth landfast first year sea ice study area near Resolute Bay, NT. Physical morphological characteristics of the surface (type, patch size, depth and percent cover) along with broadband (305-2800µm) and spectral albedo (338-950µm at 2µm wavelengths) measures were collected daily from June 5 through July 10, 2002. Spectral albedo results were integrated into visible (400-700µm) and near infrared (NIR) (700-950µm) values to explore differences between the two ranges as well as to increase flexibility of results for use in regional climate models. A relationship between digital numbers (DN) from aerial photography and albedo from surface measurements was established and regional patch statistics were calculated for distinct radiative surfaces. These relationships were then used to produce 14 albedo maps across the study site over the melt season. The maps were subsequently compared with relative broadband albedo estimates from the aerial surveys.

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Remote Sensing 2 : Coastal Zones and Oceans / Télédétection 2 : Zones côtières et océans

Chair / Président : Jim Helbig

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Session 4-C-1

Remote Sensing 2 : Coastal Zones and Oceans / Télédétection 2 : Zones côtières et océans

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Results indicate a strong relationship between the physical and optical properties of the melt surface which underpins an ability to link optical albedo estimates to microwave remote sensing in the passive and active portions of the EM spectrum. Albedo ranged from 0.65 for snow to 0.24 for deep ponds. Integrated spectral albedo for snow and transitional surfaces overestimated broadband albedo measures by 3%. This relationship increased to 5% over pond surfaces attributed mostly to the NIR absorption by water. Large differences between visible and NIR albedo where observed from snow (0.65 and 0.56) to deep water (0.24 and 0.06). Preliminary results for albedo estimates from the interpolated maps agree well with relative regional albedo calculated from the aerial surveys.

4-C-1.6

Geodetically Referenced Sea Surface Topography Over The Scotian Shelf From Satellite Altimetry

Guoqi Han[1], Brian Petrie[2], John Loder[2], and Charles O'Reilly[3]
[1] Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre, St. John's, NL
[2] Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth, NS
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Seasonal-mean sea surface topography relative to a common reference ellipsoid was produced over the Scotian Shelf from TOPEX/Poseidon satellite altimeter data in the 1990s. The altimetric results exhibited substantial seasonal variations, higher in late summer and early fall and lower in late winter and early spring. Significant interannual sea level changes were evident for the 1990s, with the sea level being lowest in 1994 and highest in 1997. Altimetric sea level estimates at the coastal tide-gauge stations are compared with in situ geodetically referenced tide-gauge observations. The altimetic and in situ results and their comparisons are discussed in the context of climatic forcing, large-scale ocean currents, and post-glacial rebound.

4-C-1.7

Estimation of Sea Surface Temperature with Passive Microwave Radiometry from the DMSP Satellites

Joseph R. Buckley[1], Andrew K. Langille[1], Igor Astapov[1]and Daniel Hutt[2]
[1]Department of Physics, Royal Military College of Canada,
[2]Defence R&D Canada - Atlantic

A tiny but measurable amount of thermal radiation from the sea surface exists at microwave frequencies and is much less likely to be blocked by cloud than is thermal radiation at the peak of the Planck spectrum in the infrared. Spaceborne passive microwave imagers can, in principle, use this radiation to estimate SST under a much wider range of atmospheric conditions than can infrared radiometers.

The peak sensitivity of microwave radiometry to changes in sea surface temperature occurs at about 6 GHz. Space borne sensors sensitive to this frequency flew in the 1970's and are incorporated into the latest microwave radiometric satellites. From 1987 until 2002 however, the lowest frequency routinely available was 19GHz, as part of the Special Sensor Microwave Imager (SSM/I) onboard the F series of satellites in the Defense Meteorological Satellite Program. It has been generally acknowledged that the range of microwave frequencies measured by the SSM/I is not well suited to SST estimation. In spite of this, we have devised a model for estimation of SST from SSM/I data, using band differences and derived geophysical parameters.

We tested the model using data collected in a region of the north-west Atlantic Ocean in the late spring of 2001 and again in 2002. Temperatures in the region varied from 2°C to 23°C. The model was calibrated with concurrent buoy data and imagery from the infrared sensors on the NOAA GOES and POES satellites. Model coefficients were determined through a singular value decomposition method, and had to be estimated separately for each data set. Within each data set, the model reproduced the calibration SST values with a mean difference of close to 0°C, and a standard deviation of ±2.5°C. The strength of gradients and the direction of isotherms were reproduced very

well by the model. These quantities were estimated consistently through cloud, in regions where thermal infrared estimates were not possible. The model could not make an estimate of SST however in regions where cloud liquid water was present. The resulting SST fields are probably not sufficiently accurate for absolute temperature estimation, but are very good for determining the distribution of thermal structures, and as interpolators for more conventional temperature estimators at times and in places where these other techniques cannot provide information.

Session 4-C-2

Canadian Society of Agrometeorology 2 / Société canadienne d'agrométéorologie 2

Chair / Président : Jon Warland

Thursday 5 June 2003

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4-C-2.1, 2

Interesting Measurements Obtained using the NRC Twin Otter Research Aircraft

R. L. Desjardins [1], J. I. MacPherson, P. H. Schuepp, E. Pattey, B. Amiro, A. Barr, L. Marht, J. Sun, T. Zhu, C. Flechard and R. Riznek
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The National Research Council Twin Otter research aircraft has been used during the last two decades to measure the carbon dioxide and water vapor fluxes over agricultural regions, over forests, over wetlands and even around urban areas all over North America. It has also been used to measure the flux of a wide range of trace gases such as ozone, nitrous oxide, methane, volatile organic compounds and agrochemicals. Examples of interesting flux measurements obtained for verifying GHG emission estimates, for characterizing the photosynthetic response of a wide range of vegetation, for determining the magnitude of trace gas fluxes from different ecosystems, for improving our understanding of atmospheric transfer and for interpreting satellite data will be presented. The accuracy of these flux measurements will also be examined using data obtained with other aircraft during wing-to-wing formation flights and with several tower-based systems during tower fly-by.

4-C-2.3

Greenhouse Gas Emissions In Barley Fields As Affected By Tillage and Soil Texture.

P. Rochette, D. A. Angers, and M. H. Chantigny
Agriculture and Agri-Food Canada

Agricultural soils are a major source of carbon dioxide and nitrous oxide in Canada. Soil management practices such as fertilizer and manure applications, crop rotations and tillage affect CO_2 and N_2O emissions. Long-term studies have shown that the effects of tillage practices on N_2O emissions are highly variable. In semi-arid environment, emissions can be lower under no-till than under conventional tillage whereas the reverse has been observed under more humid climatic conditions. A field experiment was designed to quantify the changes in N_2O emissions following the establishment of no-till vs moldboard plow systems in two soils from the St. Lawrence lowlands. Nitrous oxide emissions were measured directly in the field using chambers. The response of N_2O emissions to tillage was very different in the two soils. In the sandy soil, emissions were generally low and differences between the tillage treatments were small. In the clay soil, very high emissions rates were measured especially in the fall and the no-till treatment showed much greater rates than the moldboard plow treatment. There were no differences in either nitrate or soluble C contents between the treatments, and these two factors were not correlated to N_2O emissions. High N_2O emission episodes in the no-till clay soil occurred when water-filled pore space was 60%. The soil physical environment induced by tillage practices determines the likelihood of high-intensity N_2O emissions.

4-C-2.4

Measuring Greenhouse Gas Emissions at the Farm-Scale Using the Nocturnal Boundary Layer Budget Method

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The reduction and stabilization of atmospheric concentrations of CO_2, CH_4, and N_2O are the highest priority of the Kyoto Protocol. The agriculture sector in Canada (which includes emissions from agricultural soils, enteric fermentation, and manure management) is responsible for 26% and 68% of total CH_4 and N_2O emissions, respectively, in Canada (Olsen *et al.*, 2002). However, emissions for this sector are highly uncertain (10-50%), mostly due to the greater than 50% uncertainty in emissions estimates of CO_2, CH_4, and N_2O from agricultural soils. If more precise estimates can be obtained this may have an impact on policy-planning in the area of greenhouse gas reduction.

The nocturnal boundary layer (NBL) budget method is a measurement technique based on the NBL acting as a natural chamber in which fluxes are measured over a large area. The characteristic

temperature inversion acts like a lid at the top of the boundary layer, enclosing gases emitted from the surface. Several tethered balloon soundings of the NBL are conducted in one night. Successive profile measurements of trace concentrations are integrated over time to determine the trace gas flux.

The NBL budget method is being used in this project to measure nocturnal CO_2, CH_4, and N_2O emissions from two typical farming systems in eastern Ontario and western Quebec. Data from this project will be used to supplement continuous daytime measurements at the same locations, with the objective of eventually obtaining a more precise estimate of greenhouse gas emissions from agricultural ecosystems in Canada.

This presentation will include the experimental methods and findings from intensive NBL campaigns performed in the summer of 2002.

4-C-2.5
Methane Emission from Beef Cattle on Different Diets
Sean McGinn, Karen Beauchemin and Trevor Coates
Agriculture and Agri-Food Canada, Lethbridge AB

Abstract Methane is estimated to account for 34% of the greenhouse gas (GHG) emissions from Canada's agroecosystems with beef cattle contributing 72% of the 771 Gg of methane generatered from livestock annually. In the livestock sector, developing mitigation policy to curb methane emissions is hampered by our incomplete knowledge of 'best management practices' that generate less methane. Few studies have been done with cattle because of technical difficulties associated with making flux measurements. The objective of our research was to quantify methane production from beef cattle fed various feedlot diets typical of those used commercially in Canada, as well as novel diets that may suppress methane emissions. To accomplish this, four large chambers were employed that housed two steers per chamber. Each chamber was instrumented with open path lasers to monitor methane concentration and allow comparison of methane flux from cattle on different diets. The results from this study are intended not only to provide a database of methane emissions, but also to screen for diets that could be further evaluated in a commercial setting. In this latter trial, methane emissions will be measured from livestock in feedlot pens using a micrometeorological approach.

4-C-2.6
The Greenhouse Gas Emissions from Stored Swine Liquid Manure
Kyu-Hyun Park and Claudia Wagner-Riddle
Department of Land Resource Science, University of Guelph, Guelph, ON

Estimates of CH_4 and N_2O emissions from stored manure in Canada are quite uncertain due to the lack of *in-situ* measurement of emission for Canadian conditions. We conducted year-round study measuring GHG emission from manure slurry storage tanks which were annex to two commercial swine barns at Jarvis and Guelph, Ontario. We used the micrometeorological mass balance method, which is suitable for heterogeneous source distributions such as liquid manure storage tanks. The CH_4 emission trends followed the slurry temperature change patterns during seasons with higher slurry temperature causing higher CH_4 emissions. CH_4 emissions differed between farms due to different swine growth stages, probably caused by the nutrient composition differences between slurries. We were able to detect the presence of 'hot spot' where gas bubbles rose to the slurry surface, using the mass balance method. These hot spots were associated with sludge accumulation in the slurry tank. The yearly CH_4 mean value for these farms was approximately less than 60% of the CH_4 emission value estimated with emission factors used in the Canadian GHG Inventory for those farms.

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4-C-2.7

Laboratory Scale Measurements of Nitrous Oxide and Methane Emissions from a Hybrid Poplar (Populus deltoides x Populus nigra (DN-2 Clone))

M. C. McBain, J. S. Warland, R. A. McBride and C. Wagner-Riddle
Department of Land Resource Science, University of Guelph, Ontario, Canada

Currently, hybrid poplars (*Populus deltoides x Populus nigra*) are being evaluated in terms of their effectiveness as an evapotranspiration barrier on landfills in Southern Ontario. The goal of this study was to determine whether or not *Populus deltoides x Populus nigra* could transport landfill gas internally from the root zone to the atmosphere either via the transpiration stream and/or aerenchyma formation, thereby acting as conduits for landfill gas release. Fluxes of methane (CH_4) and nitrous oxide (N_2O) from the trees to the atmosphere were measured under controlled conditions using dynamic flux chambers and a Tunable Diode Laser Trace Gas Analyzer (TDLTGA). Nitrous oxide was found to be emitted from the trees but only when extremely high soil N_2O concentrations were applied to the root zone. In contrast, no detectable emissions of CH_4 were measured in a similar experimental trial. It should be noted that visible plant morphological responses, characteristic of flood-tolerant trees attempting to cope with the negative effects of soil hypoxia, were observed during the CH_4 experiments. Leaf, chlorosis, leaf abscission and the formation of both hypertrophied lenticels and adventitious roots were all visible plant responses. Based on the available literature, the observed hypertrophy of lenticels and the formation of adventitious roots suggest that CH_4 can be transported internally by aerenchyma tissue in *Populus deltoides x Populus nigra* trees in trace amounts, although future research is required to test this hypothesis.

4-C-3.1, 2
Verification of Spatial/Gridded Forecasts
Barbara G. Brown
National Center for Atmospheric Research, Boulder CO

Methods for verification of spatial forecasts (e.g., gridded precipitation; convective regions) are in the process of undergoing an evolution. This evolution is occurring primarily because the standard methodologies do not provide adequate information about forecast quality in the new era of mesoscale forecasts. In particular, standard measures are unable to diagnose forecast errors in a meaningful way, to provide feedback to forecast developers, forecasters, and end users. New approaches based on entities and forecast objects hold promise for providing this type of diagnostic information. This talk will review standard methodologies for verification of spatial/gridded forecasts, considering characteristics of standard measures, as well as their positive and negative attributes. New approaches – some that are "operational" and others that are under development – will also be described. The promise and benefits of new diagnostic approaches that are able to provide feedback to developers and forecasters, as well as operationally relevant information for end users – will be discussed.

4-C-3.3
Recent Trends In Skill of Weather Element Forecasts in Canada
R. Verret, G. Hardy and G. Richard
Development Branch, Canadian Meteorological Centre

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 ten years. These latter forecasts are generated with two different systems, one based on the Perfect Prog approach and the other one based on the updateable model output statistics 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

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Operational Meteorology 4 : Performance Measurement II / Météorologie opérationnelle 4 : Mesures de la performance II

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Operational Meteorology 4 : Performance Measurement II / Météorologie opérationnelle 4 : Mesures de la performance II

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improvement trend in the skill of the temperature forecasts after 1992. It is not possible to detect any trend that can be statistically significant in the probability of precipitation forecasts over the period of the study. 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.

4-C-3.4
Verification of precipitation forecasts at high resolution
Laurence J. Wilson
Recherche en prévision numérique, Dorval, Québec

As numerical weather prediction models have increased in resolution and have begun to exceed the resolution of standard surface observation networks, questions have arisen and have been hotly debated on how best to verify these forecasts. More specifically, there is considerable interest in answering the verification question of whether the smallest scale variations that are predicted by the model or forecast technique represent just noise, or can also display some degree of accuracy.

In this presentation, this issue is discussed from a rather practical verification perspective, focusing on feasible verification strategies given the different types of data that might be available. While the presentation will concentrate on verification methodology, some practical examples will be shown from the Sydney Olympics forecast demonstration project, and the MOS lightning forecast technique currently under development in RPN.

4-C-3.5
Public Weather Forecast Performance Measurement Project (PWFPM)
Pierre Pommainville
Meteorological Service of Canada, Services, Clients and Parters Directorate

In 2001, MSC has created a transition fund to support a series of initiatives to implement the new technologies needed to reduce operating costs and launch improved services. One of these goals is to build an automatic national public weather forecast performance measurement system to provide managers, forecasters and scientists with information to improve the whole end-to-end Canadian Public Weather Forecast Program. In addition, the system is expected to provide ongoing reports to Canadians, their leaders, clients and partners on how their meteorological system is performing against our commitment and funding.

The PWFPM verification software directed by Services, Clients and Partners Directorate is still on development and implies the participation of several national committees across the country. By the end of 2003, the system based on hourly metadata information is being built to generate in quasi-real time all sorts of performance measures to operational forecasters and periodic reports to managers and external users. In addition, further enhencement is expected next year to include the verification of the marine weather forecasts.

The author is proposing to provide an oral presentation to describe the PWFPM project and its integration in MSC's infrastructure. Discussion will be focused on goals, the approach, the system design and database, the access to the output measures and the expected impacts on the forecast program and to Canadians.

4-C-3.6
Assessment of the Economic Value of Forecasts
Laurence J. Wilson
Recherche en Prévision Numerique, MSC, Dorval

Weather forecasts are useful only if the user takes specific actions which vary from day to day depending on one or more forecast weather elements. In order to determine the value of forecasts, therefore, objective information must be collected on the sensitivity of the user's operations to weather events, in addition to the data needed to verify the forecast itself. Probably the simplest model for determination of the value of forecasts is the cost-loss decision theory model.

This paper gives a brief review of the two-state cost-loss decision model with an example of its application to specific weather sensitive industries. Generalizations of this model to a broader spectrum of users will also be described in the context of ensemble probability forecasts.

4-C-3.7
Delivery of Weather and Weather-related Services and Public Good
G. A. McBean
Institute for Catastrophic Loss Reduction, University of Western Ontario

Weather information is of both public good and commercial value. This has resulted in conflict between providers of such information. The US National Academy of Sciences recently published a report (for which I was co-author) and recommended some actions and principles for the US situation. This paper will examine some the issues of a publicly-funded weather service, possible private sector roles, and the balance of benefits to Canadians. It will also propose that the benefits to Canadians will be greatly extended if there was a merging of weather and weather-related information and warning services with delivery through the media to all.

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Operational Meteorology 4 : Performance Measurement II / Météorologie opérationnelle 4 : Mesures de la performance II

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Session 4-C-4

Coastal Oceanography 1 / Océanographie côtière 1

Chair / Président : Guoqi Han

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4-C-4.1, 2
Data Assimilation with Representers: An Example for the Waters around Vancouver Island
M. G. G. Foreman
Institute of Ocean Sciences, Fisheries and Oceans Canada

A representer approach is used to assimilate tide gauge harmonics into a high resolution barotropic finite element model for Puget Sound and the waters surrounding Vancouver Island. A preliminary model solution which employs a conventional coefficient value for quadratic bottom friction is shown to produce elevation amplitudes and phases that differ significantly from the harmonics arising from the analysis of tide gauge observations.

Assimilation not only rectifies this problem but also shows that this better simulation necessitates significant momentum equation residuals in regions where turbulent mixing and internal tide generation are known to be large. For the most part, these residuals may thus be viewed as estimates of additional dissipation beyond conventional bottom friction.

Application of same representer approach to a circulation model for the North Pacific will be briefly discussed.

4-C-4.3
Circulation over the Newfoundland and Labrador Shelf: A Modeling Study
Guoqi Han
Northwest Atlantic Fisheries Centre, Fisheries and Oceans Canada, St. John's, NL

Linear finite element models are implemented for the Newfoundland and Labrador Shelf to investigate barotropic tidal currents and seasonal wind- and density-driven circulation. Solutions for leading tidal constituents are forced by tidal elevations specified at the open boundary and by tide-generating potential. Monthly-mean wind-driven circulation is computed with wind stresses from the NCEP-NCAR reanalysis data prescribed at the sea surface and large-scale remote forcing specified at the open boundary determined from a North Atlantic model. Density-driven circulation is also simulated with prescribed density gradients from a temperature and salinity climatology. The model results are examined against previous model results and in situ observations. The seasonal circulation solutions are discussed for seasonal and interannual variations and for relative importance of local to remote forcing.

4-C-4.4
Tidal and flooding modelling of the Bay of Fundy
Frédéric Dupont, Charles Hannah, David Greenberg
Bedford Institute of Oceanography

A high resolution finite element model of the Bay of Fundy (down to 50~m) has been implemented. The model incorporates drying and flooding inside the domain. The computational domain includes potentially inundated areas with maximum elevation above mean sea level up to 20~m. Two large areas around Windsor and Truro have been especially targeted.

We show how well the model is doing at reproducing the tides and how we implemented a first order storm surge forcing. This system is presently used at COGS (Center Of Geographic Sciences) for comparisons with remote sensing measurement of the position of the coastline. Because the mean sea level affects the resonance properties of the Gulf of Maine/Bay of Fundy system, a future path of research is to study the impact of flooding due to long term change of the mean sea level.

4-C-4.5

Currents and Mixing in a Tidally Energetic Inlet

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[2]*Department of Earth and Ocean Sciences, University of British Columbia, Vancouver*

A two-dimensional (i. e., laterally-averaged) numerical model of the tidally energetic circulation in Burrard Inlet and Indian Arm, British Columbia is compared to observations of velocity and density in a depression near a shallow sill in Burrard Inlet. The observations show that during spring tides the density in the depression increases during weak floods and decreases during strong floods. There is an up-inlet current pulse into the depression during each flood tide regardless of the flood tide's strength. During neap tides, there are no observed pulses into the depression and the density is much less variable. The numerical model uses a level two version of the Mellor-Yamada turbulence closure scheme for which the local turbulent energy production is balanced by local dissipation and for which the turbulent length scale is prescribed. The turbulent energy production is expressed somewhat more generally than normal in that the explicit influence on it of horizontal (as well as vertical) variations in the horizontal velocity field is included. The simulation is significantly improved when this additional influence is taken into account, and much of the observed circulation can be reproduced. The model differs from the observations primarily in that the simulated current pulses are significantly weaker than the observed pulses, possibly because the cross-channel averages computed by the model may not be good estimates of the observed currents there.

4-C-4.6

A New Two-Way Nesting Technique Based on the Semi-Prognostic Method

Jinyu Sheng[1] and Richard J. Greatbatch[1], Carsten Eden[2]
[1]*Oceanography Department, Dalhousie University, Halifax*
[2]*Institut fur Meereskunde, Kiel, Germany*

Physical processes of circulation over coastal waters and shelf seas operate over a wide range of temporal and spatial scales. It is a formidable task to resolve all these different scales in numerical simulations using a single-grid model. We propose a new nesting technique for a nested-grid system that has a fine resolution inner model(s) embedded inside a coarse-resolution outer model. The new two-way nesting technique is based on the semi-prognostic method suggested by Sheng et al. (2001), in which the inner model is affected by the outer model in two ways. First, the outer model variables at the dynamic interface are interpolated onto the fine grid to provide boundary conditions for the inner model. Second, the outer model density over the common subregion where the two grids overlap is interpolated onto the fine grid to adjust adiabatically the momentum equations of the inner model based on the semi-prognostic method. Similarly, the inner model density over the common subregion is interpolated back onto the coarse grid to adjust the momentum equations of the outer model over the common subregion. We demonstrate the effectiveness of this new nesting technique based on the model results over the Meso-American Barrier Reef System of the Caribbean Sea and those over the Scotian Shelf and slope waters over the eastern Canadian shelf.

4-C-4.7

Improving Coarse Resolution Ocean Models

Dan Wright[1], Youyu Lu[1], Igor Yashayaev[1] and Keith Thompson[2]
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[2]*Department of Oceanography, Dalhousie University, Halifax*

Recent studies have shown that rather fine horizontal resolution (~1/10th degree or finer) is required to reproduce some major features of the ocean's circulation. In the North Atlantic, this includes the Gulf Stream and North Atlantic Current pathways and the net meridional heat flux carried by the ocean. Unfortunately, the manpower and computational expenses involved in such fine resolution ocean simulations can tax the resources of even the largest oceanographic research centers; multi-decadal simulations of the global ocean at this resolution are only barely feasible at a few locations.

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Thus, it remains desirable to develop ocean models of much coarser resolution that capture the features of the ocean circulation that are of climatic relevance. We consider several approaches to improving the fidelity of ocean models with horizontal resolution of order 1 degree in the horizontal. Each approach is based on nudging particular variables in specific frequency bands and within restricted geographic regions. Our goal is to determine the minimum perturbation of the model dynamics that is required to obtain significantly improved results without significantly increasing the computational expense. The pros and cons of the most successful approaches will be briefly discussed. A 50 year simulation using the method of choice with NCEP forcing will then be performed and the large scale variations in predicted water mass properties will be briefly compared with the variations suggested by observations over this period.

Session 4-D-1

Remote Sensing 3 : Atmosphere / Télédétection 3 : atmosphère

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4-D-1.1

Monitoring the Global Energy Budget and Hydrologic Cycle with TRMM and the Afternoon "A-Train"

Tristan S. L'Ecuyer[1] and Graeme L. Stephens
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The Earth's weather and climate are driven by the exchange of energy between the sun, atmosphere, surface, and space and the meridional transport of this energy required to establish a global balance. Clouds and precipitation play an integral role in this exchange, enhancing reflection of solar radiation to space, trapping thermal emission from the surface, and providing a mechanism for the direct transfer of energy to the atmosphere through the release of latent heat. As a result, there is an intimate coupling between the climate, energy budget, and global hydrologic cycle but the problem of establishing observational evidence for the resulting feedbacks and for climate change in general poses a significant challenge to the observational community.

This presentation introduces a multi-sensor algorithm that synthesizes complementary information from distinct satellite-based retrievals of high and low clouds and precipitation to simultaneously estimate the principal components of the Earth's hydrologic cycle and energy budget. Analyses of the 1998 tropical oceanic energy budget and hydrologic cycle from Tropical Rainfall Measurement Mission (TRMM) observations illustrate the utility of the method for diagnosing relationships between the water cycle and atmospheric diabatic heating on short to intermediate timescales. When combined with corresponding uncertainty estimates, these datasets provide critical information for diagnosing feedbacks in the global climate system, testing parameterizations in GCMs, and data assimilation applications.

The presentation also provides a glimpse at the future of satellite-based climate monitoring using the NASA Earth Science Enterprise's afternoon "A-train" constellation, a revolutionary concept in which six satellites will fly in formation to provide an unprecedented multi-sensor perspective of the atmosphere. In addition to extending the algorithm to high latitudes (including Canada), the combination of measurements from CloudSat's 94 GHz cloud radar and Aqua's MODIS and AMSR instruments, offers the potential for more accurate cloud detection and improved estimates of liquid and ice cloud microphysical properties, two of the dominant sources of uncertainty in the current implementation of the approach.

4-D-1.2

Comparison of Radiosonde and Radiometer Measurements with Global Environmental Multiscale (GEM) and Rapid Update Cycle (RUC) Models During the AIRS 1.5 Project

Zlatko R. Vukovic and Walter Strapp
Meteorological Service of Canada, Downsview, Ontario

Time series of water vapour path (WVP) measured by radiosonde and derived from the ground-based dual-channel microwave radiometer (23.8 and 31.4 GHz) are compared with the values obtained from the GEM and RUC models, during the 3 months of the 2002/3 winter period of the Alliance Icing Research Study (AIRS 1.5) at Ottawa and Mirabel locations. The GEM and RUC models are also compared with the radiosonde measured vertical profiles of temperature and relative humidity, and liquid water path (LWP) derived from the radiometer.

Compared fields show that differences in updating cycles, grid resolutions, and target forecast times, result in significant differences between the two models. The comparison confirms that the RUC model's WVP could be used for operational purpose when radiometer measurements are not available.

Session 4-D-1

Remote Sensing 3 : Atmosphere / Télédétection 3 : atmosphère

Chair / Président : Paris Vachon

Thursday 5 June 2003

jeudi 5 juin 2003

Room / Salle Ballroom B

4-D-1.3

The Measurements Of Pollution In The Troposphere (MOPITT) Instrument: 40 Months of Carbon Monoxide Measurements

James R. Drummond, Holger Bremer, Jane Liu, Florian Nichitiu, Jason Zou,
Department of Physics, University of Toronto,

J. C. Gille, Merritt Deeter, David Edwards, Gene Francis, Ben Ho, Dan Ziskin, Debbie Mao, Jarmei Chen, Valery Yudin, Louisa Emmons, Jonguan Niu, Gabrielle Pfister
National Center for Atmospheric Researc,

The MOPITT experiment was launched on NASA's Terra satellite on December 18th, 1999. The mission was to measure carbon monoxide and methane in the troposphere. In the last three years much data have been gathered and these data continue to shed new light on tropospheric pollution events and transport on a global scale. Data from the first 14 months of the mission have been successfully validated and are available for use by the scientific community.

This talk will present some of the "new views" that MOPITT allows on the globe and will outline some of the new studies which now become possible with these data.

4-D-1.4

Assessment of CO Emission from Biomass Burning in Canada and USA Based on MOPITT Data

Jane Liu, James R. Drummond, Jason Zou, and Florian Nichitiu
Department of Physics, University of Toronto,

Carbon monoxide (CO) is one of the important trace gases in the atmosphere. Biomass burning is generally accountable for about 25% of global CO emission. Traditionally, the CO emission from biomass burning is assessed with approaches that require knowledge on burned area and biomass density. Using CO data from the instrument of Measurements Of Pollution In The Troposphere (MOPITT) onboard Terra satellite, CO emission can be estimated independently from the traditional approaches. To explore this, the fire events in Canada and USA during the fire season of year 2000 are studied. In addition to daily CO total column and profile data, other spatially explicit data from various sources and formats are searched for and collected. These data include daily fire images, 6-hour wind profile field, land cover map and biomass density information. These data are processed to match each other in space and time. Large gaps in MOPITT data due to the present of clouds are filled with an interpolation method. Fires are analyzed under different conditions of wind speed and land cover type. Estimated CO emission is compared with that based on a traditional approach. With the emission ratios of CO/CO_2, CH_4/CO_2, $NMHCs/CO_2$, assessment of CO_2, CH_4, and NMHCs (nomethane hydrocarbons) emitted from these fires are also made. The limitations and possible biases using MOPITT data are examined.

4-D-1.5

Feasibility of Monitoring Atmospheric Carbon Dioxide Columns from a Nadir View Fourier-Transform Infrared Spectrometer

Dmitry Yashcov [1] and Boyd T. Tolton [2]
[1] *University of Toronto, Department of Physics*
[2] *Synodon Inc., Edmonton, Alberta*

Long term observations of the global distribution of Carbon Dioxide (CO_2) concentrations are necessary to understand the role of anthropogenic CO_2 in climate change. Although atmospheric CO_2 can easily be detected by remote sounding techniques, the precision that is required to make scientifically useful measurements is difficult to achieve. This is due to the fact that the spatial and temporal variations in CO_2 concentrations are small relative to the total amount in the atmosphere. Observations with sensitivity of 1 ppmv or better would be revolutionary in our understanding of atmospheric carbon cycle.

A feasibility study has been performed to identify the potential of a Nadir-View Fourier-Transform Infrared Spectrometer for atmospheric CO_2 measurements with such precision. The results of this study will be presented.

4-D-1.6
The MAESTRO Instrument on SciSat-1: one component of the Atmospheric Chemistry Experiment
C. Thomas McElroy
Meteorological Service of Canada

An instrument called MAESTRO (Measurements of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation) will fly in 2003 as part of the Canadian Space Agency's SciSat-1 mission, the first Canadian science satellite in 30 years. Along with a Fourier Transform Spectrometer (FTS), which is the principal instrument of the Atmospheric Chemistry Experiment (ACE), MAESTRO will make measurements of tropospheric and stratospheric composition with particular emphasis on the Arctic stratosphere during the late winter and early spring when ozone depletion events occur. There are a number of important issues related to the processing of occultation data which must be properly handled if high-quality data products are to be obtained. Some of these, such as the absorption of light by water and molecular oxygen, and the assignment of the vertical height scale for the observations are critical to making accurate extinction measurements, particularly in the upper troposphere. The data processing algorithms being written will be described and the results from tests of some of the retrieval concepts using data from MANTRA balloon ascents and ER-2 aircraft flights will be presented.

4-D-1.7
Realistic Detailed Model Generated Cloud Scenes for Earthcare
Alain Beaulne, Wanda Szyrmer and Jean-Pierre Blanchet
Département des Sciences de la Terre et de l'Atmosphère, Université du Québec à Montréal

The EarthCARE mission is a joint European-Japanese satellite proposition with the aim of better understanding the interactions between clouds, aerosols and radiative processes. For this project, a numerical simulator is being built to assess the performance of the mission. A cloud-resolving model is used to produce various high-resolution cloud scenes suitable for the simulator study.

The cloud-resolving model is based on the dynamics of the Mesoscale Compressible Community Model (MC2), which use a semi-implicit semi-lagrangian numerical scheme for integration of the fully elastic nonhydrostatic Euler equations. For warm clouds, the microphysics considers the presence of droplets and drizzle, with cloud droplet spectrum evolution being computed explicitly. For cold clouds, mass mixing ratios and concentration are predicted for three categories of condensed water, namely the cloud droplets, pristine ice crystals and snow crystals.

In this presentation, the main characteristics of the cloud-resolving model and the strategy for scenario creation will be presented in addition to various cloud fields produced by the model.

Session 4-D-2

Canadian Society of Agrometeorology 3 / Société canadienne d'agrométéorologie 3

Chair / Président : Jon Warland

Thursday 5 June 2003

jeudi 5 juin 2003

Room / Salle Panorama

4-D-2.1

A Multi-Layer Model Incorporating Lagrangian Dispersion to Address the Relationship between Leaf and Canopy Resistance

Adriana C. Furon, Jon S. Warland and Claudia Wagner-Riddle
University of Guelph

The validity of the leaf-to-canopy translation of surface conductances is still under debate. One approach usually used to assess this scaling up problem involves interpreting the *bulk stomatal resistance* of the canopy as the effective resistance of the leaf components acting in parallel. This type of formulation is called 'the integrated canopy stomatal resistance' whose value is then compared against the (residual) value of canopy resistance obtained by inverting the Penman-Monteith equation. Even if it is acknowledged that this canopy resistance cannot be a purely physiological parameter defined in terms of leaf resistances alone, it is still important to know to what extent these two resistances differ, thus inferring the significance of the problem for practical purposes.

Numerical simulations were used in this study to address the scaling up problem. For this purpose, a simple multi-layer canopy model was coupled with a Lagrangian dispersion matrix to provide the profiles of temperature, humidity and CO_2 within the canopy. The leaf stomatal conductance is modeled in two ways: one approach uses the relationship with net radiation proposed by Denmead and Millar (1976) for wheat whereas the other approach incorporates the empirical model presented by Ball, Woodrow and Berry (1987) where leaf conductance is dependent on net assimilation, relative humidity and CO_2 concentration at the leaf surface.

This study examines the effects of friction velocity, leaf area magnitude and distribution, soil parameterization and atmospheric conditions on the relationship between bulk and leaf surface resistances. Results from each model of leaf conductance are examined to explore the impact that feedback mechanisms within the canopy (Ball and Berry model) may have on this relationship.

4-D-2.2

The Application of Airborne Pollen Dispersal Modeling to Regulatory Risk Assessment for Genetically Engineered Plants

Franco Di-Giovanni[1],
[1]*AirZOne One, Inc., Mississauga, Ontario*

Peter Taylor[2]
[2]*Department of Earth and Atmospheric Science, York University*

Increasing attention has been paid to human and environmental impacts of genetically modified crops. Within Canada, the Canadian Food Inspection Agency has responsibility to assess, and approve for release, any new plants (including genetically modified ones) introduced into Canada. As part of the environmental risk assessment for these plants pollen flow from these plants to the surrounding environment may need to be considered. Where information is required on pollen-flow (and thus gene-flow) frequencies at various distances, for totally or partially wind-pollinated crops, regulators have sometimes relied on isolation zones for seed production and confined field research trials. These zones were determined from information based upon plant breeder experience and a very limited number of field trials, and may not be applicable to locations, environmental conditions or field seasons other than those experienced during the study's execution. Since gene-flow and pollen dispersal are highly variable phenomena, instances of the breakdown of isolation zones have been noted. Segregation from sexually compatible plants is an important consideration, and is used to preserve seed purity, prevent the entry of unapproved events into the food and feed supplies and is also of interest to the organic farming community. Due to the zero tolerance policy for admixtures of novel traits in organic crops, adequate segregation may present a real challenge for organic growers. This has led to controversy in North America, with the Saskatchewan Organic Directorate attempting to launch a class-action lawsuit against two major biotech companies based upon gene flow from genetically modified canola.

We describe a novel application, which aims to quantify the variability and frequency of pollen-flow for wind-pollinated plants based on well-established principles from the air pollution field. A Langevin equation dispersal model was developed and tested against various datasets. The results of this model will be compared to off-the-shelf U. S. EPA models (ISC3-ST and/or AERMOD-PRIME) to pragmatically choose the most appropriate model. Ultimately, the choice will be inferred by model validation results as well as practical considerations in application and in regulatory use. The chosen model will be applied to quantify the variability of pollen movement under varying environmental conditions and at different locations and thus provide probability distributions for pollen-flow. The use of this tool will allow regulators, or those with responsibility for crop segregation, to more accurately define gene-flow under differing levels of containment corresponding to differing levels of segregation, or product "purity," and at different localities and conditions.

We describe some of the physical and biological mechanisms underlying pollen- and gene-flow in wind-pollinated plants, discuss in general terms the variability found in previous measurements of pollen- and gene-flow and then describe how mechanistic modeling of the physical and biological mechanisms can greatly enhance risk assessments and the effectiveness of gene-flow management. We then describe past work on developing models for the forestry sector in Ontario, Canada, and then discuss the initial stages of work with the Canadian Food Inspection Agency in applying these methods to agricultural crops. Finally, we describe the applications of such a modeling system for regulators.

Session 4-D-2

Canadian Society of Agrometeorology 3 / Société canadienne d'agrométéorologie 3

Chair / Président : Jon Warland

Thursday 5 June 2003

jeudi 5 juin 2003

Room / Salle Panorama

Session 4-D-3

Operational Meteorology 5 : MSC Update / Météorologie opérationnelle 5 : nouvelles du SMC

Chair / Président : Fred Conway

Thursday 5 June 2003

jeudi 5 juin 2003

Room / Salle Ballroom C

4-D-3.1, 2
MSC - Focusing for the Future
Marc Denis Everell
MSC

The Minister for the Environment, David Anderson, recently announced an investment of $75M over five years to modernize and revitalize the MSC. The plan is to improve services to Canadians by bringing science and operations together to bear on the problem of forecasting high impact weather, by increasing the MSC capacity for outreach to weather-sensitive industries, by improving partnerships with academe, other levels of government and industry (particularly the value-added meteorological sector) and by modernizing the monitoring networks, ensuring their integrity and that of the archives. All of this means an interesting future for meteorology in Canada. It will mean increased involvement of the university research community, a better understanding of the needs of Canadians and in particular those sectors of the economy most affected by weather including agriculture, forestry, transportation, etc and better data access for and collaboration with the Value-Added Meteorological sector. Dr. Everell will speak to the opportunities that the new investment will bring to all stakeholders in the MSC.

4-D-3.3
Data Management Framework for The Meteorological Service of Canada (MSC) Operational Monitoring Networks
Michael Minuk and Tsoi-Ching Yip
National Archives and Data Management Branch AMWSD, MSC, Environment Canada

The purpose of the Data Management Framework is to depict MSC monitoring data flow from creation through its various transformations to distributed repositories, the national archive and data distribution portal for external access. This framework is designed to be a template to add new monitoring data sources and streamlining existing monitoring data flows and specifically address issues related to:

- Data quality assurance and quality control both in real-time and non-real-time modes
- Metadata related to monitoring data.

A number of principles are developed to address issues related:

- "Official" MSC value for Monitoring Data and other official MSC data types e. g. forecasts
- Data encoding/decoding algorithms & data transmission protocols
- Data history and transformation.
- Data access by Public to archived and real-time data.

MSC is planning to modernize its data management infrastructure and the long-term Climate and Water Archives. The goal is to create a paperless environment so that observational data will be captured and quality controlled in both real-time and non-real-time. Quality data are made available to users in a timely fashion.

4-D-3.4
A Status Report on the Reference Climate Station and the Surface Weather Networks
Yves Durocher
MSC

Environment Canada has revised the Reference Climate Station (RCS) Network and the Surface Weather (SWX) Network. The list of RCS stations has been revised and now includes all GCOS surface network (GSN) stations and CORE stations. The list of 302 RCS stations now includes not only stations with historical long period of uninterrupted record of quality observations but also "RCS

in the making" which are stations chosen for the expected quality of the station's observation in the future. The same new standard configuration is used in both networks for all modernized (automated) stations (wherever possible), thus effectively enlarging both of those networks. Although the modernized stations in these 2 networks will look identical to users, they will be managed according to their respective network : RCS stations will be protected to ensure continuity in their long period of uninterrupted quality observations and some homogeneity of distribution across the entire country to support climate change detection while SWX stations will be managed according to the forecast (and warning) requirements.

The standard configuration includes the precipitation sensors evaluated and selected over the last 4 years. A new series of evaluation and selection processes is starting this fiscal year for the temperature, humidity, wind and pressure sensors.

Modernisation has already been completed at 70 stations (including RCS, SWX and GSN). Another 35 stations are planned for 2003/04. A standard set of algorithms has been defined for these stations and implementation of the new release of the telecommunication software will provide new elements in real-time in BUFR formats and in the National Archive.

4-D-3.5
Development of the Canadian Aircraft Meteorological Data Relay (AMDAR) Program - An Update
Gilles Fournier
Chair, Canadian AMDAR Program Implementation Team, Meteorological Service of Canada

The Canadian AMDAR Program is a cornerstone of the modernization of the Canadian Upper Air Program. After a Business Case on the benefits of a Canadian AMDAR Program was presented to the Canadian air carriers in March 2000, the Meteorological Service of Canada formed the Canadian AMDAR Program Implementation Team (CAPIT) to oversee all aspects of the development of the Canadian AMDAR Program. CAPIT membership includes Nav Canada, Canadian air carriers, a representative from NOAA/FSL and the Technical Officer of the WMO AMDAR Panel.

Progress on the development of the Canadian AMDAR Program will be presented. The development has started with two regional airlines, Air Canada Jazz and First Air. First Air is an airline servicing the northern communities of Canada such that a datalink system different from the ACARS based system had to be developed. Preliminary results from the testing of an alternative AMDAR system based on the Internet and a Low Earth Orbiting communications satellite will be presented.

4-D-3.6
Current Status and Future Improvements in the Canadian Meteorological Center's Analysis and Forecasting System /
Statut actuel et améliorations futures au système d'analyse et de prévision du Centre Météorologique Canadien
Yves Pelletier, André Méthot
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). The current status of the operational system will be reviewed . Recent and planned improvements will be described . These include improvements in data assimilation, and transition efforts toward the IBM supercomputer architecture. The availability of CMC operational products (charts, images, bulletins, GRIB, BUFR, etc) will be reviewed, and a new product guide will be introduced.

Session 4-D-3

Operational Meteorology 5 : MSC Update / Météorologie opérationnelle 5 : nouvelles du SMC

Chair / Président : Fred Conway

Thursday 5 June 2003

jeudi 5 juin 2003

Room / Salle Ballroom C

4-D-3.7

New CMC products - GRIB Data and Other Products / Nouveaux produits du CMC - Données GRIB et autres produits

Yves Pelletier, Lewis Poulin
Operations Branch, Canadian Meteorological Center

This presentation reviews recent initiatives at CMC that have increased the availability of GRIdded Binary (GRIB) data and color images of model data. A publicly available GRIB database is now in place. Users can access various types of grib data via an interactive web-based interface or they can program their computers to get the grib data automatically. This database greatly increases the access to high quality model data for the research community, the private sector and the public. CMC is also putting in place a database offering a broad selection of new color images showing data from CMC operational production. These new images will give our regional offices, and eventually the public, a broader and better selection of model imagery on the web. Images are easily accessible via an interactive web interface offering functionality appropriate to a weather office environment. The images database may also serve as a new source of image bundles which could eventually be delivered to various regional offices. Finally, helpful hints will be presented on how to take advantage of other popular viewers to easily display CMC model data.

Session 4-D-4

Coastal Oceanography 2 / Océanographie côtière 2

Chair / Président : Guoqi Han

Thursday 5 June 2003

jeudi 5 juin 2003

Room / Salle Pinnacle

4-D-4.1

Update on the Lunenburg Bay Project

Serge Desjardins [1], Hal Ritchie [2], Garry Pearson [1], Andrew Phillips [1]
[1] *Meteorological Service of Canada -Atlantic Region*
[2] *Recherche en Prévision Numérique, Meteorological Service of Canada, Dorval*

At the last CMOS held in Rimouski, it was mentioned that MSC would be involved in the World Junior Sailing Championships that were to be held in mid-July 2002 in Lunenburg. Environment Canada offered support to this international event by providing an on-site meteorologist. The gains from MSC's participation to this event have been enormous, in term of visibility and public relation with the summer sailing community. It was also mentioned that the sailing event was seen as a golden opportunity to develop a modeling framework for the Lunenburg Bay project. Two year ago ,MSC along with public and private sector partners got together to develop a meteorological and oceanographic observation network at Lunenburg. The network will allow scientists to collect, analyze and assimilate data, in addition to validate high resolution numerical models. The complete network will eventually collect atmospheric, wave, ocean circulation, and biological observations. The ultimate goal is to assemble atmospheric and oceanic data assimilation and modeling systems into a coupled environmental prediction system to forecast environmental variability in the Lunenburg Bay, and the adjacent coastline for the short and long-term. Such environmental system will allow, for example, a better understanding of meteorological phenomena such as local sea breezes, coastal effects, local-scale wind patterns, and possibly improve our comprehension of sea fog formation.

In the presentation, a retrospective of MSC participation to the sailing event will be done as well as the progress done in the Lunenburg bay scientific project. A lot of effort in the last year have been spent to develop an on-line tool to make use of the temperature and wind profiler observations which would be used to validate outputs from future high resolution modeling of the bay. On-line wind/temperature comparisons between observations and regional or HIMAP GEM outputs will be presented at the conference. One hopes to present comparison between wind observations and outputs from 1 km MC2 simulations that were done last year or if the higher resolution are re-initiated for the summer to present more current wind comparisons.

Have peek on: http://www.atl.ec.gc.ca/weather/wind/index_e.html

4-D-4.2

A Three-Dimensional Coastal Circulation Model for Lunenburg Bay, Nova Scotia

Liang Wang and Jinyu Sheng
Dalhousie University, Halifax, Nova Scotia

We developed a high-resolution (60 m) eddy-resolving coastal circulation model for Lunenburg Bay, Nova Scotia, using the free-surface version of CANDIE (sheng et al., 2001). To assess the model performance, we use this high-resolution bay circulation model to simulate the barotropic tidal circulation in the bay during two different periods: (a) the first two weeks of September, 1991; and (b) September to the mid-November, 2002. Since surface wind was relatively weak during the first period, we force the model with only the tidal forcing specified at the model open boundaries, which is inferred from the tidal predictions at Lunenburg Harbour provided by the Canadian Hydrographic Service. The model results agree very well with the observed surface elevations and slightly less well with the observed currents made in the region during this period. For the second period from September to mid-November, 2002, we force the bay circulation model with tides, surface wind and shelf waves calculated by the shelf circulation model known as Dalcoast. The model results agree reasonably well with the observations made by a newly-established marine environmental prediction system in Lunenburg Bay. We also run the tidal circulation model in baroclinic mode to examine the influence of tidal mixing in the region.

Session 4-D-4

Coastal Oceanography 2 / Océanographie côtière 2

Chair / Président : Guoqi Han

Thursday 5 June 2003

jeudi 5 juin 2003

Room / Salle Pinnacle

4-D-4.3

Variable Resolution Near Shore Circulation Modelling in the Bay of Fundy

David Greenberg[1], Fred Page[2]
[1]*Fisheries and Oceans Canada, Bedford Institute of Oceanography*
[2]*Fisheries and Oceans Canada, St. Andrews Biological Station, St.Andrews, NB.*

The aquaculture industry within the southwest New Brunswick area of the Bay of Fundy has grown from its first farm in 1978 to an industry operating over 90 farms and worth over $200 million dollars annually. The industry is concentrated in the nearshore - often within 100m of the shoreline. Over the past 5-10 years governments and industry have recognized that knowledge of the local water circulation patterns is of fundamental importance and practical value to informed decision making concerning the continued development and sustainability of the industry. Hence, a three dimensional finite element circulation model was developed that incorporates variable spatial resolution and routines to simulate the wetting and drying of intertidal areas. The model will be described and its performance in relation to sea level and current meter observations will be presented. The usefulness of the model to coastal processes, including aquaculture and coastal zone management will be identified.

4-D-4.4

Sustainable Development Issues facing Finfish Aquaculture in the Bay of Fundy - - Application of a Tidal Circulation Model

Fred Page[1], David Greenberg[2]
[1]*Fisheries and Oceans Canada, St. Andrews Biological Station, St. Andrews, NB*
[2]*Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth, N. S.*

The aquaculture industry within the southwest New Brunswick area of the Bay of Fundy has grown from its first farm in 1978 to an industry operating over 90 farms and worth over $200 million dollars annually. As the industry developed governments and industry recognized the value of having input on water circulation and particle transport patterns for various decisions. Hence, a fine scale three dimensional finite element circulation and particle transport model was developed. The model has been used to develop advice for input into decisions concerning the selection of farm sites, the spread of fish disease, the interaction between farming and other components of the coastal environment and the influence of faring on concentrations of dissolved oxygen. The presentation will give a brief overview of the model and provide details on the model's applications.

4-D-4.5

Current and Hydrographic Variability on the Scotian Slope, 2000-2002

Yuri Geshelin[1], John W. Loder[1] and Brian D. Petrie[1], Guoqi Han[2]
[1]*Bedford Institute of Oceanography, Dartmouth, N. S.*
[2]*Northwest Atlantic Fisheries Center, St. John's, NL*

Initial results from a current and hydrographic measurement program on the Halifax section across the Scotian Slope between June 2000 and October 2002 are presented. Current meter moorings on the 300-, 1100 and 2000-m isobaths during differing portions of this period provide indications of cross-slope, seasonal and interannual variability in the currents and hydrography. Sea surface slopes from TOPEX/Poseidon altimetry data, surface temperature data from satellite imagery, and seasonal occupations of the Halifax hydrographic section (as part of the Atlantic Zonal Monitoring Program) are used to identify larger-scale influences and help interpret the moored measurements. Comparisons are made with historical currents data from Scotian Slope and with climatological seasonal-mean currents from a circulation model. Preliminary results indicate general southwestward flow on the middle slope with a barotropic component and seasonal variation, and a major disruption in the flow in the upper 500m during spring 2002 resulting in northeastward flow along the shelf edge (instead of the southwestward flow in the climatological model).

4-D-4.6

A Seventy-Year Record of Dwindling Deep-Water Oxygen Levels in the Lower St. Lawrence Estuary

Denis Gilbert [1], Bjorn Sundby [2,3], Charles Gobeil [1,4], Alfonso Mucci [3], Anne de Vernal [5], Gilles Tremblay [1], Claude Hillaire-Marcel [5]
[1] *Maurice Lamontagne Institute, Fisheries and Oceans Canada*
[2] *Institut des Sciences de la Mer, Rimouski*
[3] *Department of Earth and Planetary Sciences, McGill University*
[4] *Institut National de la Recherche Scientifique (INRS)-Eau-Terre-Environnement, Sainte-Foy*
[5] *Centre de recherche en Géochimie et en Géodynamique/UQAM*

Dissolved oxygen concentrations in the bottom waters of the Lower St. Lawrence Estuary have decreased by 50% since the early 1930s and are now below the 62.5 µM threshold defining hypoxia. The hypoxic zone, which presently covers approximately 1000 km^2 of the seafloor, is permanent and expanding, causing concerns about deleterious impacts on deep-water and benthic organisms, including fish. A consideration of the factors that may cause oxygen depletion in the bottom waters leads us to believe that increasing fluxes of terrigenous or marine organic matter to the sediment are responsible. These increased fluxes of organic matter to the sediment may in turn be caused by anthropogenic activities such as deforestation and the relatively recent introduction of chemical fertilizers in agriculture.

4-D-4.7

Influence of the Surface Horizontal Wind on the Circulation of the Gaspé Current as Simulated by the Canadian Regional Climate Model (CRCM) and the Gulf Of Saint-Lawrence Ocean Model (GOM)

Dorothée Charpentier [1], Daniel Caya [2] and François Saucier [3]
[1] *Université du Québec À Montréal, Montréal, Québec*
[2] *Ouranos Consortium, Montréal, Québec*
[3] *Ocean Sciences Branch, Maurice Lamontagne Institute, Fisheries and Oceans Canada, Mont-Joli, Québec*

One of the main characteristics of the Gulf of Saint-Lawrence surface circulation is without doubt the Gaspé Current. It is a buoyancy-driven coastal jet originating in the Saint-Lawrence Estuary attaining its maximum along the north shore of the Gaspé Peninsula after merging with the Anticosti gyre circulation. The Gaspé Current presents an important spatial and temporal variability in its strength and position. This current, dynamically unstable, presents two modes of circulation. It can be observed along the coast of the Gaspé Peninsula or separated and almost attached to the coast of the Anticosti Island. Some studies associate this variability to instability mechanisms like a change in the runoff conditions or an important wind forcing.

We present an investigation of the influence of atmospheric fields, especially surface horizontal wind, on the variability of the Gaspé Current. Numerical simulations performed with the Canadian Regional Climate Model (CRCM) and the Gulf of Saint-Lawrence Ocean Model (GOM) are used to analyse the Gaspé Current response to changes in the wind after an evaluation of the internal variability of the system. The experience consists of an exchange of atmospheric and oceanic fields needed for the surface forcing in each model with an execution of three iterations by the two models over the same period of one year. The internal variability is evaluated with nine eight-month simulations with perturbed initial conditions in GOM. Results show a shift of the Gaspé Current maximum following the maximum of the surface horizontal wind intensity, especially during the autumn season.

Session 4-D-4

Coastal Oceanography 2 / Océanographie côtière 2

Chair / Président : Guoqi Han

Thursday 5 June 2003

jeudi 5 juin 2003

Room / Salle Pinnacle

Poster Session A

Session d'affiches A

Tuesday 3 June

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Penthouse Lobby

Niveau penthouse

PA.1

Basic Attempt to Include Wave-Ice Interaction in a WAM Model

Denis Jacob, Ronald Frenette et Viateur Turcotte
SMC - Québec Region

During the 3 to 6 months of our winter most of the interior waters are 50 to 90 % ice covered. Any attempts to use actual wave models during that period is doomed to failure. Using a recent adaptation of a WAM model, we embedded some of the major interaction between wave and ice such as damping of the waves in ice and the effect of the ice presence to the source input and the source dissipation. Only a qualitative evaluation of the results has been done yet using the very rare ships wave observations in the Gulf of St. Lawrence.

Durant la période hivernale qui dure de 3 à 6 mois la plupart des eaux intérieures sont couvertes de 50 à 90% de glace et par conséquent les prévisions de vagues issues de modèles ne tenant pas compte de ce phénomène est voué à l'échec. À l'aide d'une adaptation locale du modèle WAM, nous avons ajouté des algorithmes qui tiennent compte de l'interaction vagues et glace. Ces ajouts ont eu pour effet d'amortir la propagation des vagues dans la glace , de réduire l'énergie associée à la création de vagues et d'augmenter la dissipation de l'énergie lors de présence de glaces. Actuellement on a fait qu'une évaluation qualitative des résultats à cause de la rareté des observations de vagues dans le Golfe et le fleuve St-Laurent cependant les résultats obtenus semblent être très prometteurs.

PA.2

A Parameterization of the Roughness Length for the Air-Sea Interface in Free Convection.

Kenzu Abdella[1], Serge D'Alessio[2]
[1]*Department of Mathematics, Trent University*
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The response of the upper ocean to the parameterization of roughness length on the air side of the air-sea interface is studied using a one-dimensional mixed-layer model. In particular, it is shown that in the free convection limit when both the wind speed and the friction velocity approach zero, the familiar Charnock formula for the momentum roughness, which relies solely on wind generation, can be modified to account for contributions arising from the thermally generated turbulence. Therefore, a new parameterization is proposed for the momentum roughness length which extends the Charnock formula down to zero friction velocity. The value of the parameter which enters in the new formulation is determined by making use of the existing free convection surface flux parameterizations. The effect of the new parameterization on the model performance is tested using data from the ocean weather ship station Papa (OWSP), and data from the Long-Term Upper-Ocean Study (LOTUS) experiment.

Simulations were carried out using a recently developed one-dimensional second-order, turbulence closure scheme over diurnal as well as seasonal time scales. The findings suggest that the new momentum roughness parameterization improves the overall agreement between the observed and simulated sea-surface temperature (SST).

PA.3

Improving Operational Wave Forecasts Using A High Resolution Wave Model During A Two-Month Period: December 2002 - January 2003

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The Canadian Meteorological Centre (CMC) operational ocean wave model (WAM) for the Northwest Atlantic runs on a coarse 1.0° x 1.0° grid covering the area 25N - 70N and 80W - 15W. The WAM produces wave forecasts out to 48 hours twice daily (0000 UTC and 1200 UTC) using the

10 m level wind forcing at 3-hourly intervals provided by CMC's Global Environmental Multiscale (GEM) weather prediction model. Running in parallel with the coarse grid WAM is a fine grid WAM which has a grid resolution of 0.5° in both latitude and longitude directions and covers the area 25N - 70N and 78W - 0W. The Maritimes Weather Centre (MWC) uses the wave products from the WAM as guidance in the preparation of its wave forecasts for distribution to its clients. The main focus of this study is to assess the performance of the fine grid WAM against that of the coarse grid WAM during a two-month period December 2002 - January 2003. December and January are typically stormy months in Atlantic Canada and several intense storms tracked across the Canadian Offshore waters during this period providing excellent test cases for this study. With a view towards improving operational wave forecasts, model output will be compared with wave height measurements from the Canadian and American East Coast buoy networks.

PA.4

The Effect of Surfactants on Air-Sea Gas Transfer

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Gas exchange across the air-sea interface is an important pathway in the global bio-geo-chemical cycling of many gases. Quantifying air-sea gas fluxes is important in understanding biological processes in the upper ocean [Emerson 1987] and accurate estimates of CO_2 transfer rates between the atmosphere and ocean are important for predictions of global warming [Banner and Peregrine 1993]. Recent observations suggest that surface-active materials present naturally in lakes and seas have a significant effect on free surface behavior and hence on the rate of gas transfer [Frew 1997]. The presence of surfactants influences the propagation characteristics of waves and alters the near-surface turbulent length and velocity scales. These effects are thought to inhibit surface renewal and therefore reduce the rate of air-water gas and heat transfer [Saylor et al. 2000]. Recent laboratory experiments in a wind-wave tank have shown that the presence of a surfactant results in up to a 60% reduction in the gas transfer rate [Zappa *et al*. 2001].

In this study, we completed a series of experiments in a wind-wave flume at the University of Washington, Seattle. Measurements were made at wind speeds from 4 to 10 m/s with clean and surfactant contaminated water. Digital Particle Image Velocimetry (DPIV) was used to measure the two dimensional turbulent velocity fields beneath the air-water interface. Bulk gas transfer velocities were determined during these experiments for two gases, He and SF_6, by supersaturating the water with the gases and measuring the decrease in their concentration over time. These experiments were unique because they included measurements of the turbulent flow generated beneath wind-waves for both clean and surfactant contaminated water surfaces.

The DPIV data has been used to obtain mean velocity profiles from 1-mm below the fluctuating free surface to depths of approximately 10-cm. The properties of the mean velocity profiles under clean and surfactant contaminated water surfaces are compared at five wind speeds. Independent measurements of the friction velocities in the boundary layers in the air and water were acquired. It was found that the shear stress across the air-water interface was not continuous. That is, the shear stress in the water was considerably lower than the shear stress on the air-side for both clean and surface contaminated water surfaces. The observed gas transfer rates were significantly lower across surfactant contaminated water surfaces compared to clean surfaces at the same wind speed.

PA.5

Progress on Understanding the Impact of Sea Spray in Extra-tropical Hurricanes

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It has long been recognized that the evolution of hurricanes and typhoons may be strongly affected by the air-sea flux transfer processes over ocean. High winds in a hurricane can generate large amounts of spray, which can modify the transfer of momentum, heat and moisture across the air-sea interface. However, whether or to what extent the sea spray can affect the hurricanes, especially the extratropical hurricanes, mid-latitude storms, or winter storms, has remained elusive. In this study, the impact of sea spray on mesoscale numerical simulations of extra-tropical Atlantic hurricanes is investigated using a coupled atmosphere-sea-spray modeling system. This modelling system consists of the MC2 atmospheric model (version 4.9.3) and a bulk-type formulation for the heat and momentum effects of sea spray from Andreas and DeCosmo (1999, 2002).

Two case studies of extratropical hurricanes, Earl and Danielle from 1998, are analyzed. We found that: (1) sea spray can cause a significant latent heat flux increase of up to 20% of the interfacial fluxes in Earl, and up to 70% of the interfacial fluxes in Danielle; (2) taking into account the effects of sea spray, the intensity of a modeled extratropical hurricane can be increased by 20% in 10-m wind speed in Earl, and 30% in Danielle; (3) the maximum deepening of SLP and the maximum enhancement of surface winds due to sea spray occurs on the high-wind side near the hurricane center. Overall, sea spray has a notable impact on extratropical hurricane evolution. These results were corroborated by *a third* case study involving the intense meteorological "Superbomb" that developed during January 20-22, 2000. Winds reached high levels ~45m/s. Sea spray effects on latent heat, in the formulation used here, were as high as 78% of the turbulent flux values. This significantly increased storm intensity so that Superbomb surface winds were enhanced by as much as 15m/s.

PA.6

A Record of Foraminiferan and Ostracoda Change between 6800-8300ABP from Lake Core 98-2-A at Barrow, Arctic Alaska

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It deals with foraminiferan and ostracoda sediments in the Arctic lake at Barrow. The lake core 98-2-A with length of 77 cm was from Elson Lagoon (71°17'53" N, 156°24'07" W) under water of a depth of 2.6 m. The whole of the core was separated by centimetre). 11 species of foraminiferan belonging to 7 genera from 45 samples of the core are Ammotium cassis (Parker), Asterellina pulchella (Parker), Buccella frigida (Cushman), Elphidium bartletti Cushman, Elphidium clavatum Cushman, Elphidium excavatum alba Feyling-Hanssen, Elphidium orbiculare (Brady), Elphidium sp., Elphidiella groenlandica (Cushman), Polymorphina sp., and Trochammina nana (Brady). Ostracoda collected from 5 samples are Cytheromorpha macchesneyi (Brady and Crosskey), Para cyprideis pseudopunctillata, Heterpcyprideis sorbyana (Jones), Paracyprideis pseudopunctillata Swain, and Rabilimis septentrionalis (Brady). These foraminiferan and ostracoda distributed in the core have four sediment stages. First stage (8300aBP-8073aBP) is at bottom of the core, the species of foraminiferan are only 2 belonging to Elphidium genera. Environment in the time didn't fit the growth of foraminiferan. Second stage (8073aBP -7375 aBP) has Asterellina pulchella, Elphidium clavatum Cushman, Elphidium excavatum alba Feyling-Hanssen, Elphidium orbiculare, Elphidium sp., and Elphidiella groenlandica. Elphidium sp. is prevalent. Body and hull of foraminifer are almost fragmentized, and their color is light yellow. It show they are foreign. It is high energy environment under surf. Third stage (7375 aBP -7055 aBP) has Elphidium sp., Asterellina pulchella, and Elphidium orbiculare, et al. The population is many, and their color is milk white. They are belonging to a place by birth. Ostracoda has still Cytheromorpha macchesneyi, Para cyprideis pseudopunctillata, and Heterpcyprideis sorbyana in the stage. Sea level was high in the stage. Fourth stage (7055 aBP - 6847 aBP) has Asterellina pulchella, Trochammina nana, and Elphidium sp.. But their population is small. Ostracoda has a small quantity of Paracyprideis pseudopunctillata Swain, and Rabilimis septentrionalis. This is particularities of foraminiferan and ostracoda in modern environment at Barrow, Arctic. This research was financially supported by funding from National Natural Science Foundation of China (49971078).

PA.7

A Record of Sedimentary Environment Change between 7000-14000 ABP From Lake Core 98-5-A At Barrow, Arctic Alaska

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It deals with foraminiferan and ostracoda sediments in the Arctic lake at Barrow. The lake core 98-5-A with length of 177 cm was from Elson Lagoon (71°19'54" N, 156°26'35" W) under water of a depth of 2.5 m. The whole of the core was separated into 177 samples by centimetre). The grain size of each sample was measured by a laser grainmeter. The degrees of the laser grainmeter have 100 degrees. Data of the grain size of 98-5-A were analyzed by R factor analysis. The fomer three eigenvalues are 44.18, 11.06, and 8.54. The percentage of the first eigenvalue is 57.4%, the accumulative percentage of the second eigenvalue is 71.7%, the accumulative percentage of the third eigenvalue is 82.8%. The positive end of incidence to the first main factor includes 0.25-0.20 mm, 0.20-0.15 mm, 0.15-0.125 mm and 0.125-0.10 mm (size is between 0.25-0.10 mm). While the negative end is fine grains, mainly including 0.1-0.07 mm and 0.07-0.05 mm (size is between 0.1-0.05 mm). Obviously, it is the most important factor which indicates the changes between continental substance source and ocean current substance source, and the first main composition is terrigenous. The positive end of incidence to the second main factor is the sediments, whose size is more than 0.07 mm, While the negative end is the sediments, whose size is less than 0.07 mm. So 0.07 mm is the division value between bed load and suspended load, which reflects the sedimentary dynamic conditions. The second main composition is fluvial facies or coastal deposits, whose opposite is lacustrine deposits. The third main factor is the sediment (<0.07 mm); and the negative end is sediments (>0.20 mm). From the viewpoint of incidence degree, the negative incidence of the sediments (>0.25 mm) is remarkable; there is no incidence in the sediments (0.2-0.7 mm); the positive incidence of the sediments (<0.07 mm) is relatively stable. It is the third main factor that reflects the changes of gravel composition, and the third main composition is gravel composition. It is record in the core that change of sendimentary environment has four stages: before 12000 aBP, between 12000aBP to 9700aBP, between 9700aBP to 8000aBP, after 8000aBP. This research was financially supported by funding from National Natural Science Foundation of China (49971078).

PA.8

Tracing Arctic Ocean Halocline Waters

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According to a recent view, the halocline is formed as Atlantic water enters through Fram Strait encounters ice to become fresher and colder. This Fram Strait branch subsequently becomes capped by fresher layer containing river runoff, thus forming the Lower Halocline. An additional contribution comes from Pacific water that is modified in the shallow shelf seas north of Siberia forms the Upper Halocline. We have identified a second source of Lower Halocline water, which originates in the Barents Sea. This Barents Sea branch closely flows close to the Eurasian coast in the Makarov Basin and Canada Basin north of the Alpha-Mendeleyev Ridge, then spreading and making up most of the Lower Halocline in the southern Canada Basin. All three halocline components can be seen exiting the Arctic Ocean through Fram Strait east of Greenland. Some of the Barents Sea branch halocline also exits the Arctic Ocean via Nares Strait into Baffin Bay.

PA.9

Compare Of The Climate Change Between The Arctic and The Northern America During The Last Glaciation

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If the unique geographical location of Arctic has the start-up influence on the climate change on the Northern Hemisphere and what is the relationship of climate change between the Arctic and other areas on different time scales? This paper will provide some evidence to give a positive answer by comparing the climate change in Arctic and the Northern America during last glaciation. Here we use the SSA(Singular Spectrum Analysis) and Similarity Analysis method.

Larry Benson et al.(1997) presented evidence of four major oscillations in the hydrological balance of the Owens basin, California, that occurred during the last glacial termination(17.7-11.5kyr ago)(10). Dry events in western North America occurred at approximately the same time as cold events recorded in Greenland ice, with transitions between climate regimes in the two regions taking place within a few hundred years of each other(10). Abrupt Climate Oscillations During the Last Deglaciation in Central North America have been researched by the Zicheng Yu, et al.(1998). We compared δ18O, total inorganic carbon (TIC) and pollen records for core OL84B obtained from the Owens basin in 1984 using a modified Livingstone piston corer (7) with δ18O record from GISP2 during the last glacial termination, note that the 14C age model for core OL84B is accurate to only a few hundred years, which implies that the δ18O record from OL84B could lead or lag the δ18O record from GISP2; that is, oscillations present in both cores cannot be demonstrated to be synchronous (10). At Crawford Lake after ~6500 14C yr B. P., the d18O profiles (8) are no longer correlative with Greenland isotopic records, which suggests that the climatic regime appears to have changed and that climatic change occurred more frequently on a regional basis(9).

Recent studies of the Greenland ice cores have offered many insights into Holocene climatic dynamics at decadal to century timescales(4 5 6). Despite the abundance of continental records of Holocene climate, few have sufficient chronological control and sampling resolution to compare with the Greenland findings(3). The F. S. HU et al. (1999) results(2) provide an opportunity to test whether decadal to century scale climate changes observed in Greenland ice also occurred near the centre of the North American continent. We have compared five-century Northern Hemisphere geothermal reconstructions with three multi- proxy reconstructions(1)and draw a conclusion that the differences between the various reconstructions may arise in part because of the different geographical distribution of the data used in the respective reconstructions. What we will do here is to clarify the respectively differences and coincidences to find the relationship between the Arctic and the Northern America. δ

Acknowledgement: This research was financially supported by funding from National Natural Science Foundation of China (49971078).

PA.10

Compare of the Climate Change Between the Arctic and Europe During the Last Glaciation

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Considerable effort has been given recently to combining several proxies in order to produce global, hemispheric and regional-scale climate reconstructions (8-4), (3-1). So these provide some evidence to compare the climate change between the Arctic and Europe on different time scales during the last glaciation and to predict how those changes may influence future climates(11). A Mid-European Decadal Isotope-Climate Record (Oxygen-isotope ratios of precipitation (§18OP)) inferred from

deep-lake ostracods from the Ammersee (southern Germany)) from 15,500 to 5000 Years B. P.(9) shows many the rapid climate shifts in central Greenland ice cores of Holocene(10). Deviating millennial-scale trends, however, indicate that climate gradients between Europe and Greenland changed systematically, reflecting a gradual rearrangement of North Atlantic circulation during deglaciation(9). The Greenland ice cores show strong quasi-periodic climatic oscillations during the longer term interglacial-glacial and glacial-interglacial transitions, Similar features have been found for Europe in long continental records of vegetation and magnetic sediment properties (2), as well as in marine proxy records (3). Although correlates for the interstadials recognised in GISP2(14)can be identified in the Monticchio record(core M25/4-11, core M25/4-12)(12) in southern Europe before 65 kyr ago, the latter shows far more detail than the ice-core data with evidence of additional fluctuations. In addition, the availability of multi-proxy data from Monticchio reveals the complexity of the environmental changes. The records of N. pachyderma (s.) from DSDP-609 and of §18O from GISP2 can be correlated with the Monticchio record, demonstrating a link between the Atlantic climate system and the central Mediterranean region(12). Correlations become more difficult before 65 kyr ago, perhaps reflecting dating problems in the DSDP-609 and GISP2 records as a result of the age modelling approaches applied(16,17) We use lightness of Bermuda Rise sediment(13)compared with ice core §18O from the GRIP2 during the last interglacial period. 17 intervals correspond to interstadial events identified in the ice core record. All events from 3kyr to 110kyr are identifiable in both cores, and the correlation of the two set of data is very well. So by comparing the climate change during the last glaciation between the two continent, the correlation of the climate change between the Arctic and Europe is drawn. Acknowledgement: This research was financially supported by funding from National Natural Science Foundation of China (49971078).

PA.11

Generation of Gridded Long Term Average Monthly Precipitation and Temperature for Canada

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Long term average regional monthly precipitation and temperature are fundamental data required for many types of studies. However, such data are collected at discrete points that are unevenly distributed in space. In Canada, the climate station network is concentrated in populated areas in the southern part of the country resulting in large areas of the country where very few stations exist. The data from these stations are discrete points that must be interpolated onto a grid in order to be used in other studies.

The object of this study is to develop gridded maps of the monthly long term average temperature and precipitation for Canada that give the best estimate of these properties where no climate data exist.

Many techniques exist to interpolate data from discrete points, the technique used for this study is an interpolation method based on station physiographic properties known as the 'square-grid' technique. It uses station coordinates, station elevation, and a number of derived physiographic characteristics as independent variables in a regression analysis of the station data. The regression will result in a set of equations that relates the value of the climate data to a selection of the physiographic characteristics. These equations can then be used to calculate the expected values of the climate data for all of Canada.

The gridded data resulting from the regressions will be examined to determine their uncertainty. An understanding of this uncertainty will help users of the data to determine if it is accurate enough for their needs. Also, looking at the patterns of this uncertainty may help to guide where future climate stations should be placed for the greatest benefit.

Final maps of long term average monthly precipitation and temperature are presented along with their corresponding uncertainty.

The next stage of this study will see the incorporation of streamflow data into the climatic records. There are many remote areas that do not have climate information but have streamflow records spanning many years; these streamflow records contain information that can be related to the amount of precipitation that has occurred over that watershed.

PA12

Étude de la sursaturation dans les modèles qui utilise la microphysique des nuages

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Dans cette étude on fait une analyse théorique de la méthode de calcul de la sursaturation moyenne et de la sursaturation en fonction du temps, à partir de la méthode analytique et stochastique et une validation de nos hypothèses avec un modèle CRM de haut résolution.

La nécessité de ce travail est basée sur les questions suivantes :

1. Est-ce que c'est correct de garder constante la sursaturation dans les simulations pour un pas de temps ?
2. Comment trouver la sursaturation d'équilibre ?
3. Quelle est la variabilité temporelle de la sursaturation dans les nuages ?
4. Comment peut-on déterminer l'intégrale de la sursaturation pour un pas de temps de la simulation ? Pour répondre à ces questions, nous avons commencé avec l'étude théorique de la sursaturation.

La saturation est une variable importante dans le modèle climatique. Une sous-estimation de son rol dans la microphysique du nuage conduite à des résultats non réalistes à la fin de simulations. Annuler la sursaturation à la fin de chaque pas du temps d'un modèle, donne, dans le plus part de temps, une surestimation d'énergie latente changée avec les systèmes dans les processus de changement de phase. Le bilan énergétique n'est pas le seul affecté par la saturation. L'activation du noyaux de condensation et du noyaux glaçogens est très sensible à la valeur de la sursaturation dans le nuages.

Introduire la variation temporelle de la saturation dans les modèles est, donc, nécessaire. On distingue deux cas différents :

1) le pas de temps est plus petit que le temps de relaxation de la saturation
2) le pas de temps est plus grand que le temps de relaxation de la saturation

La solution de l'équation différentielle de la saturation pour les nuages chauds et les nuages froids permette le calcule d'intégrale de la saturation dans le cas d'un pas de temps plus petit que le temps de relaxation de la saturation (1).

Dans le cas d'un pas de temps plus long que le temps de relaxation, le modèle calcule la saturation d'équilibre, qui devient la saturation initiale dans le pas de temps suivant (2).

Quand les deux intervalles de temps sont comparables on considère le premier cas. Les résultantes obtenues avec les simulations faites avec le CRM de haute résolution conduisent à la validation des nos hypothèses.

PA.13

Projet d'atlas climatique du Québec septentrional, 1970-2000

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En 2001, débutait un vaste projet d'étude sur le climat du Québec septentrional. L'objectif principal du projet est de construire une climatologie plus fine du Québec septentrional (Nord et Moyen-Nord) et d'en dégager les tendances, la variabilité et les extrêmes climatiques des trois dernières décennies. Il s'agit là d'une occasion unique de documenter le climat du Québec nordique sur la base d'un registre instrumental d'une haute résolution spatio-temporelle. En effet, la majorité des variables de température et de précipitation qui seront analysées dans le cadre de ce projet présentent des enregistrements aux 15 minutes et, proviennent d'une banque de données inédites à de la Direction du suivi de l'état de l'environnement du Ministère de l'Environnement du Québec (Service de l'information sur le milieu atmosphérique). Également, des données issues des stations d'Environnement Canada et du réseau de télémétrie environnementale du Centre d'études nordiques de Université Laval viendront compléter cette base de données. Ce projet qui mènera à l'achèvement d'une climatologie à la fois globale et plus fine du Québec septentrional est attendu depuis de nombreuses années. Maints ouvrages consultés ont formulé le vœu, et plusieurs chercheurs (biologiste, géomorphologue,…) attendent encore aujourd'hui la compilation de ces données pour le prolongement, la complétion ou l'affinement de leurs recherches. Le cadre méthodologique de ce projet de recherche ainsi que quelques résultats préliminaires vous seront présentés.

PA.14

Carbon Flux in Regional-Scale Oceanic Climate Models

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Biosphere affects the climate by modifying the radiative, momentum, and energy and water budgets. While oceanic primary production represents about half of the planet's primary production (i. e. photosynthetic uptake of carbon), oceanic respiration (i. e. remineralization to CO_2) is identified as one of the major components of the carbon flux in the biosphere. The remainder of organic carbon is transfered to the pelagic food-web and/or exported downward from the euphotic zone. A key question when trying to understand the global carbon cycle is whether the oceans are sources or sinks of carbon. This will depend on the production of organic matter relative to the decomposition due to respiration. Paradoxically, localized upwellings are strong drivers of primary production in many regions of the open ocean, but the regional impact of such hot spots is poorly represented by the low resolution of coupled atmosphere-ocean global circulation models (GCMs) used to simulate global carbon uptake. This poster presents an overview of the ability of current regional-scale oceanic climate models to parameterize biologicial activities in order to reflect our current understanding of oceanic carbon flux dynamics.

PA.15

Project to Intercompare Regional Climate Simulations: Experiment 1C Validation of CRCM Simulations

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Potential impacts of climate change on agriculture, water resources, human health and ecosystems are tied to climates of regions (e. g., provinces, countries or states) rather than to changes in broad continental or global averages. It is therefore imperative to understand and, ideally, to predict how global climate change is manifested at these regional scales. Because of GCM coarse resolution that is insufficient to represent climate at regional scale, much attention has been devoted in recent years to climate simulation using atmospheric RCM driven by GCM output or atmospheric analyses. The overall strengths and weaknesses of this method have been difficult to assess, in part because of the disparate applications and lack of a common framework.

The Project to Intercompare Regional Climate Simulation (PIRCS) provide a common simulation framework for evaluating regional models run in climate mode, both versus each other and, more important, versus observations, in order to improve regional climate simulations. The results of the first experiments (1A and 1B) showed some problems in evaluating the performance of the models mainly because of the short integration period (two months) and a too small domain covering the U. S continent. Therefore, a new experiment (PIRCS 1C) was defined on a more appropriate domain that extends to the Gulf of Mexico and uses a larger integration period of 3.5 years (1 July 1986 - 31 December 1989) where the first six months are spinup. Preliminary results obtained with the Canadian RCM (CRCM) in this new PIRCS experiment will be presented.

PA.16

Influence of Domain Size and Large Atmospheric Wave Nesting in Internal Variability Studies with RCM's

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Variability in climate simulations, performed with a Regional Climate Model (RCM), is mainly influenced by three sources: the lateral boundary forcing, the surface boundary forcing and the internal variability of the model itself. Climate simulations, using different initial conditions, should share the same climate because the information given at the lateral boundaries controls the RCM simulations. On the other hand, RCM are used to get realistic fine-scale details, which change the global atmospheric circulation and could therefore lead to some discrepancies at the lateral boundary outflow. RCM's challenge is to get as perfect as possible a combination between the lateral boundary forcing, which control the simulation, and the model internal variability, which develop fine-scale details, to get optimal climate simulations. Following experiments by Caya and Biner (2003), new tests are presented here. A new set of one-year simulations have been done with the Canadian RCM on a larger domain, which covers most of North America, with NCEP reanalysis lateral boundary condition and nesting of large atmospheric waves. We expect that the larger domain will lead to greater discrepancies, compared to the previous experiment, between members of the ensemble of climate simulations. Larger domain allowed more space to the RCM to develop is own climate and thus reduce the control of the lateral boundary condition on the simulation. However, nesting of large atmospheric waves will increase the control of the driving lateral boundary condition over the simulation. Analysis of old and new pairs of simulations will allow to increase our understanding of the impact of the domains size and nesting control, especially during summer season where intense stochastic subgrid scale processes affect strongly the atmospheric circulation.

Caya, D. and Biner, S., (2003) Internal Variability of RCM Simulations over an Annual Cycle, Submitted to Climate Dynamics.

PA.17

Regional Climate Modeling with a Spectral Element Atmospheric Model

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The spectral element method combines the meshing flexibility of the finite element method and the high-order accuracy of the spectral method. In this study, we develop a hydrostatic Spectral Element Atmospheric Model (SEAM) in the generalized terrain-following vertical coordinates (h) for global and regional climate modeling. One goal is to couple SEAM with the physics module of the NCAR CAM (Community Atmosphere Model) to build SEAM as another dynamical core for CAM. We present some results from: (a) the dynamical core experiments using SEAM with Held-Suarez forcing; (b) the aqua-planet experiments using SEAM coupled with CAM physics; (c) preliminary experiments using SEAM coupled with CAM physics, CLM2 (Community Land Model), and the sea

ice model; (d) same as (c), but with local mesh refinement, such as times 3 over the continental United States.

Acknowledgement: We thank Mark Taylor for discussion on the earlier version of the SEAM model, and many staff members at CGD/NCAR for sharing their knowledge of CAM and CLM. We also thank John Drake and Pat Worley for help on understanding the dynamics-physics coupling module in CAM.

PA.18

Multi-Model Ensemble Climate Predictions Using Ridge Regression

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Canadian Centre for Climate Modelling and Analysis, Victoria

Abstract: Ridge regression is used to produce deterministic climate forecasts from an ensemble of individual forecasts from a group of climate models. The method is applied to an ensemble of 850 hPa temperature forecasts derived from the Atmospheric Model Intercomparison Project (AMIP2) integrations performed by 12 different modeling groups. Forecasts are verified against NCEP reanalyses. Forecast skill is measured in terms of mean square error. In most cases, a ridge regression forecast was able to outperform the standard multi-model regression forecast. However when comparing with the performance of the regression improved ensemble mean forecast in which all model are treated equally ridge regression offers only minor improvements in the Tropics where potential predictability on seasonal time scales is relatively large and in the extratropics for small ensemble sizes. With increasing the multi-model ensemble size, the regression improved ensemble mean forecast generally outperforms all other forecast variants considered.

PA.19

Water Resource Impacts of Climatic Warming vis-a-vis Mountain Glaciers

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Department of Earth and Ocean Sciences University of British Columbia

It is well-recognized that long-term climatic warming trends, whether natural or anthropogenic, could affect runoff through depletion of glacial ice reservoirs. However, both the precise nature of such proglacial runoff changes and the broader downstream water resource implications remain ambiguous, and theories largely remain empirically untested. We address this issue by applying nonparametric statistical techniques to historical time series of total annual river flow volume. The study area is an approximately climatologically uniform region within the southwestern Canadian subarctic, and data from nine hydrometric stations, sampling drainage areas up to ~16,000 square kilometres, were analyzed. Statistically highly significant relationships between streamflow trends and presence and degree of watershed glacial cover were found. In particular, every glacier-fed river grew progressively larger, whereas each nival stream grew smaller, under an observed simultaneous climatic warming trend. Trends in total yearly discharge volume also appear to be accompanied by progressive changes in the form of the annual hydrograph. The results, which appear to be readily physically interpretable, have implications for climatic, ecological, glaciological, and water resource research, management, and planning.

PA.20

Earth to Mars: The Great Model Switch

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[2] *Dalhousie University, Halifax*

The single-column model (SCM) of the Canadian Center for Climate Modeling and Analysis (CCCMA) is a 1-dimensional radiative transfer model used to study Earth's atmosphere. The CCCMA SCM is taken into new territory and application through modification to represent the atmosphere of Mars. Current understanding of the physical relationships in atmospheric science is tested in a variety

of numerical models such as the SCM. The models are written for Earth's atmosphere, based on its climate, composition, processes and dynamics. Physical information about the planet itself is also included in models and the model calculations are based on these and other constants, as well as equations describing the processes and relationships in the atmosphere. Despite differences in physical planetary characteristics and atmospheric composition, the atmospheric processes of another planet, understandable in terms of universal laws, should be able to be simulated using Earth based models. By studying a variety of climates, insight is gained into Earth's atmosphere, as well as the strengths and limitations of a model. Here the modified model is employed to study the Martian atmosphere using data from the Mars Pathfinder mission, in particular, the temperature inversion observed in the temperature profile during entry.

Observations from Mars Pathfinder and Mars Global Surveyor (MGS) show deep temperature inversions occurring both near the surface and extending as high as 20 km. Some of the inversions start above the surface and extend over a few kilometers (Colaprete, 2000 and Haberle, 1999). The cause of these inversions is theorized to be the result of radiative cooling in response to the cold nighttime surface temperature. An alternate source for this radiative cooling is water ice clouds, as they can have a significant effect on the thermal structure of the nighttime atmosphere (Haberle, 1999). The imager for Mars Pathfinder (IMP) observed cloud systems in the early morning on various sols (1 sol equals 1 Martian diurnal cycle) during the mission (Colaprete, 1999). Evidence for early morning water ice clouds is also found in Martian images from the Space Hubble Telescope, however the altitudes of the clouds have not been uniquely determined (Magalhaes, 1999).

Atmospheric conditions are varied in the model in attempt to recreate and sustain the nighttime inversion in the presence of water ice clouds. Sensitivity studies focus on the presence of dust and water vapour in the atmosphere. The sensitivity studies also investigate the radiative effects of both dust and water vapour in the atmosphere by comparison to clear atmosphere conditions (no aerosols or water vapour).

PA.21

Development of a Mars Spectral General Circulation Model with Chemistry and Aerosols in Support of Future Mars Missions

Stephen Beagley [1], Victor Fomichev [1], Youssef Moudden [1], Ayodeji Akingunola [2], Antonio Garcia Munoz [1], John C. McConnell [1], Diane Michelangeli [1], Ulrike Lohmann [3], Charles McLandress [4], Theodore Shepherd [4], William Ward [5]

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NASA, ESA, and Japan all have plans that involve a major thrust in the exploration of Mars in the next 10 years. In addition, the CSA has recently been supporting Mars activity: Canadian components of NASA Scout missions, Phoenix (Allan Carswell, Optech) and MICA for MARVEL (Jim Drummond, UT) are being supported through Phase A. Northern Lights (Benn Quine, YU/Toth Technologies) may have an opportunity for a lander mission and Dynamo, a Michelson Interferometer for measurements of winds on Mars (W. Ward, UNB) has a possible opportunity with the CNES MARS mission. The stability of the atmosphere appears to be maintained by chemical reaction with a geologically short time scale of 2000 years while aerosols driven off the surface are extremely important in the heating of the atmosphere. Thus a GCM with chemistry and aerosols covering the atmosphere from the surface to the thermosphere would provide a powerful tool to support these and other planetary activities. Also with an ionosphere as part of the model this could also support the data analysis of ionospheric data from the Thermal Plasma Analyser (A. Yau, UA). The model that we are using is a modified version of the extended Canadian Middle Atmosphere Model which currently goes from the ground to 200 km. One form has already been installed on the NEC that resides at the UT. We have started to modify it in stages. The first step consists in obtaining a dynamic model for Martian atmosphere with the surface topography and realistic initial conditions, this step will allow us

to assess the coherence and the stability of the dynamic part in a Mars context. A physics package including a non-LTE radiative scheme, parameterization of the seasonal CO2 condensation and water cycles, PBL, surface energy budget etc will be added or modified from the current modules. An F1-type ionosphere will follow when resources allow. One of the reasons for suggesting covering the whole atmosphere would be to allow studies of rapid mixing in the upper atmosphere. Mixing is so rapid in the thermosphere (10-100 times that of the earth) that O and CO are minor species throughout most of the thermosphere. The cause of this mixing is but it seems likely that gravity waves and the large scale circulation play a role. In the lower atmosphere, an important question for Mars is the distribution of water vapour. With a GCM such as we are proposing it would be possible to gauge whether or not various FTIR and possible UV-vis instruments could meet experiment design requirements. Thus with a combination of measurements of CO, ozone, water, perhaps OH, as well as p, T measurements we might be able to build up a picture of the location of water sources in the permafrost and some idea of how the water moves around, escapes to space (in the form of H and O atoms) for many Martian years.

PA.22
On the Numerical Simulation of Mars Atmosphere
Antonio García Muñoz
Department of Earth and Atmospheric Science, York University

Since it is penetrated by UV light of 200 nm and greater the Martian atmosphere is potentially very unstable on geological time scales, e.g. the observed CO can be produced in around 2000 years. The long term goal of the present work is to study some of the physico-chemical features needed in the correct modelling of the Martian atmosphere. It is well known that the high computational load and complex coupling of phenomena in more realistic 3-dimensional computational codes prevents them from being manageable tools for the testing of basic physico-chemical models. This difficulty becomes more patent in unsteady simulations. Hence, it is usual to resort to simpler (0- or 1-dimensional) approaches at early stages of the validation of the models. A 1-dimensional code has been written for this purpose, which describes the temporal variation of constituents in a gas column. Account is taken of vertical diffusion and photochemistry. Prior to the testing of models itself a review of the numerical aspects that can affect the solution is made. Features as computational cost, accuracy, stability and spurious behaviour of the space and time difference operators in both, steady and unsteady computations, are analyzed in a number of illustrative examples. Also, an extension from equally spaced grids to adaptive ones is carried out. Some preliminary conclusions on the photochemical models are drawn as well. A continued insight into this latter point will be undertaken hereafter.

PA.23
Surface Scheme for a Mars General Circulation Model
A. Akingunola, J. C. McConnell
York University, Toronto

The movement of water in the Mars atmosphere is important for the development of the polar caps and possibly life processes. Important in this respect is the movement and storage of water in the surface which is largely tempered by soil and surface temperatures. As part of the development of a GCM model for Mars, a surface parameterization project has been undertaken to simulate the time evolution of surface temperature on Mars and related processes such as the PBL and surface boundary layer. The work seeks to produce an accurate simulation of heat flow to/from the surface layer from/to the atmosphere, in order to determine correctly the diurnal and seasonal surface temperature variations. This is also important in order to determine the movement of water vapour in and near the surface. The parameterization uses a multi-layer soil model which uses thermal inertia data from the Mars Odyssey THEMIS instrument. When fully developed, the model will also take into consideration the latent flux due to condensation/sublimation of CO_2 at the surface. We will present results showing the impact on temperature and water vapour.

Poster Session A

Session d'affiches A

Tuesday 3 June

lundi 3 luin

Penthouse Lobby

Niveau penthouse

PA.24

DYNAMO, An Imaging Interferometer for Satellite Observations of Wind and Temperature on Mars

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As in the terrestrial atmosphere, the state of the Martian atmosphere is determined through a complex interplay of chemistry and dynamics. Correct interpretation of data requires inclusion of dynamical and constituent signatures and an understanding of the working of the atmosphere requires consideration of radiative, constituent and dynamical effects. The DYNamical Atmosphere Mars Observer is a low mass field-widened Michelson interferometer designed to measure wind and temperature in the Martian atmosphere. To date there have not been any direct observations of winds on Mars - this instrument is designed to address this gap in our knowledge. This instrument is specifically designed to measure Doppler shifts in emissions in the O_2 infra-red atmospheric band at 1.27 microns (although it may be possible to measure other airglow emissions as well). The instrument concept which has been developed has an overall mass of ~16 kg, will require < 10W of orbital average power and will produce ~32 Mbits of data per day. These parameters, including the pointing requirements, are well within the capabilities of typical multi-instrument spacecraft platforms that have been and will be used in Martian orbit.

In this poster, details of the instrument and its potential scientific impact are presented.

PA.25

An Airglow Imaging System for Gravity Wave Observations at the Martian Atmosphere

Stella M L Melo[1], and K. Strong[1], K. Gilbert[2], R. P. Lowe[2], T. Slanger[3], D. Huestis[3], M. J. Taylor[4], N. Rowlands[5],
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It is well known that atmospheric gravity waves can act as a coupling mechanism, transporting energy and momentum from the lower to the upper atmosphere. On Earth, one consequence of gravity wave momentum deposition is the development of a strong meridional flow from the summer pole to the winter pole. This meridional flow results in the ascent of air parcels (implying adiabatic cooling) in the summer mesopause region, and descent (implying adiabatic heating) in the winter mesosphere. This accounts for the observed deviation of the temperature structure at mesopause altitudes from what would be expected if it were in radiative equilibrium.

Airglow is an amorphous, non-auroral and non-thermal radiation continuously emitted by a planetary atmosphere. The main source of energy is the absorption of solar producing excited species that can either react with other species or re-emit the excess energy. The excited species tend to distribute in relatively thin vertical layers (in Earth, generally about 10 km) due to the combination of source processes on the upper side and loss through collisions in the lower side. Gravity waves modulate the constituents and temperature and consequently the airglow layer. Therefore, airglow imaging has been proved to be a useful technique for measuring gravity wave activity, allowing retrieval of parameters such as the wave amplitude, horizontal wavelength, direction of propagation, phase velocity, and wave period.

There is considerable evidence of vertically propagating gravity waves in the Martian atmosphere. Although existing radiative-convective and general circulation models reproduce the general features of the thermal structures in the lower Martian atmosphere, the observed thermospheric temperatures are lower than the model results. It has been shown that the introduction of gravity waves drag in the models can reconcile models with observations. Indeed, some model results suggest that gravity wave drag can account for the cold thermospheric temperatures by warming adiabatically the atmosphere via dynamically induced circulation. The Martian airglow is only poorly known. Although dayglow UV measurements go back to Mariner's days, there are no observations in the visible spectral region. It has been observed that the most intense emission in the UV region is the CO Cameron bands between 190 and 270 nm. In the infrared, the O_2 Atmospheric band at 1.27 µm is the most intense airglow feature with intensities up to 26 MR (megaRayleigh).

We are proposing to develop a zenith-sky imaging system (MARES) that will monitor from the ground the wave activity in the Martian atmosphere through measurement of the contrast in the image of selected airglow features. Using available global circulation models for Mars atmospheric composition and temperature together with a gravity wave model we will simulate the wave signature in each of these atmospheric fields. We will then build an airglow model that uses the wave disturbed fields to estimate the airglow response to gravity waves. Through this modeling exercise we will define the target emissions for MARES.

PA.26
Utilisation du Bootstrap dans les Prévisions Météorologiques
A. Mouiha·
Dépt. De Maths et Informatique, Faculté des Sciences Dhar Mehraz, Fès,MAROC

Les prévisions météorologiques sont modélisées généralement par une série chronologique, ce qui demande un échantillon d'une grande taille d'ordre plus d'une trentaine d'observations pour pouvoir supposer la Normalité des observations, en particulier la normalité du bruit blanc du modèle à étudier. Cependant, en réalité, souvent nous ne disposons pas de données suffisantes pour faire nos prévisions, surtout dans les pays en voie de développement. Nous adoptons alors une méthode Bootstrap (Voir : Künsch (1989), A. Mouiha & N. Rais (2000), pour les détails de la méthode). Cette méthode consiste a rééchantillonner un très grand nombre d'échantillons, dites échantillons bootstrap, à partir de l'échantillon initial, et ainsi le problème de la taille de l'échantillon ne se pose plus.

PA.27
Forecasting Mixed-Phase Clouds and Precipitation with the New Regional GEM Model
Anna Glazer and Andre Tremblay
Meteorological Service of Canada, Montreal

The Canadian Meteorological Center must be in a position to accurately forecast summer severe weather events, intense snowfalls, and to be able to identify the type of precipitation (rain, snow, ice pellets, freezing rain or drizzle, or mixture of these) reaching the surface. One of the key research objectives of the Cloud Physics Research Division is directed at improving cloud microphysics in the Canadian forecast system. As a result the mixed-phase cloud scheme has been developed. The scheme produces three-dimensional forecasts of cloud microphysics structures and is recently implemented in the new Canadian CMC GEM-DM. The mixed-phase cloud scheme allows the prediction of various cloud and precipitation types typical of the Canadian climate and responds to the forecast needs of many economically important sectors. A detailed comparison of the current operational CMC regional forecast model with the new mixed-phase scheme will be presented.

PA.28
Canada's Contribution to Argo in Observing the Ocean Real-time

Anh Tran and Cara Schock
Marine Environmental Data Services (MEDS), DFO

Prediction of climate variability depends on our ability to observe ocean variability. Argo is a relatively new international program where by up to 3000 robotic diving floats will collect temperature(T) and salinity(S) profiles in the world oceans and transmit data in real-time without any restrictions to all users.

Argo will provide a quantitative description of the evolving state of the upper ocean and the patterns of ocean climate variability. Data provided by Argo and other observation programs will feed in to the Global Ocean Data Assimilation Experiment (GODAE) which will supply the first forecasting tools for the ocean climate. Argo supports the concept of Operational Oceanography.

Deployments for Argo began in 2000. Floats will cycle to 2000m depth every 10 days, with a 4-5 year lifetime for individual instruments. As of January 2003, the global Argo network consisted of 620 active floats deployed by fifteen countries in the Atlantic, Indian and Pacific oceans. Canada made its first deployment on June 9, 2001 and to date has contributed 76 floats to the program with a total of 2507 profiles. Typically, about 90% of the data are distributed within 24 hours of the float surfacing. The current profiling float used in Canada , built by the Webb Research Corporation , could supply up to 200 profiles over its lifetime.

The objective of our poster is to show Canada's contribution to the Argo program. The Canadian Argo data system will be described showing the various stages that the raw data goes through to become completed T and S profiles. Comparisons between data collected from Argo floats and other instruments will be discussed, as well as some products available now and coming soon to users.

PA.29

A Corelation Between Concentration of SO_2 and Black Smoke in the Air and Asthmatic Attacks in Skopje, Macedonia

Olivija Todorovic, Radmila Simeva, Dr Lidija Markovska
Hidrometeorological Service of Republic of Macedonia

The total surface area of the Republic of Macedonia amounts to 25,713 km^2 and is predominantly mountainous country with 34 peaks over 2000 m. above sea level. Skopje as a capital of the R. of Macedonia, represents an administrative, cultural, industrial, and traffic centre, where big number of different industrial capacities are located: chemical industry, metallurgy, textile industry, cement production, metal processing industry etc. According to the 1994 census, Skopje has 541,280 inhabitants. The Skopje basin with its orographic and climatic characteristics, has very unfavourable (from the ecological aspect) top climatic specifics.

The temperature inversions in the Skopje basin are present in every month of the year, especially during the winter months and anticyclone conditions, with all negative manifestations. The temperature difference, in an inversion condition, between the lower parts of the valley and the roundabout mountain massive, during the winter months, can reach 10°C, that depends of the intensity and the thickness of the inversion layer. During the winter months the number of days with fog is increased, mainly of radiation character. Such climatic characteristic of the Skopje valley, the concentration of industrial capacities and population, leads to disorder of adopted air quality standards. The air quality condition in Skopje, the Hydrometeorological Service performs its monitoring more than 30 years.

As a result, in the modern society and urban environment, climatic condition and atmospheric pollution are becoming more important causes of the development of bronchial asthma. This paper presents the correlation between monthly average values of 24-hours concentrations of SO_2, monthly average values of black smoke and monthly average values of asthmatic calls (the people are aged between 18 and 70) for the period of 10 years (1990-2000). Correlation coefficients between these

parameters are greater then 0.7. The linear regression lines show high correlations. Most of the investigations done on the relation: polluted air - population health (especially population that suffer of asthma) are conducted manly in winter, which is the most critical period from the aspect of air pollution.

PA.30

Health Impact of Extreme Summer Temperatures in Iberia

Ricardo García-Herrera[1], Julio Díaz[2], Ricardo Machado Trigo[3] and Emiliano Hernández Martín[1]
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Recently, a great effort has been made to evaluate the effect of extreme temperatures in human health. Most attention has been paid to quantify the temperature impact on mortality through the use of different statistical tools, such as generalised additive models, Box-Jenkins models or Poisson regression models. Such variety of models can create additional difficulties when trying to compare results obtained in different environments, not favouring the characterization of the role played by local factors. On the other hand, less attention has been paid to the analysis of the meteorological patterns associated with the mortality extremes. This paper examines the effect of extreme summer temperatures in two large cities of Iberia: Lisbon (Portugal) and Madrid (Spain). In both of them the same methodology (Box-Jenkins) is applied to quantify the impact of summer extreme temperatures in mortality. To facilitate a meaningful comparison of results we have also applied a similar procedure to evaluate the corresponding meteorological patterns associated with extreme temperatures in both cities. . Mortality has been computed as number of daily deaths for all causes and genders, while daily maximum temperature has been used to measure thermal impact.

Results reveal that in both cases there is a triggering effect when maximum daily exceeds a given threshold. However, this threshold is lower in Lisbon (34C) than in Madrid (36C), which is naturally related to the proximity of the Atlantic Ocean in Lisbon's case. Nevertheless, the impact of most heat waves is very similar for both cities, with significant mortality values occurring up to 3 days after the temperature threshold has been surpassed. The impact is measured as the percentual increase of mortality associated to a 1ºC increase above the threshold temperature. In this respect, Lisbon shows a higher impact, 31%, as compared with Madrid 21%. The difference can be attributed to demographic and socio-economic factors. In particular, the longer life span of Iberian women is critical to explain why, in both cities, females are more susceptible than males to heat effects, with an almost double mortality impact value.

The analysis of SLP, 500hPa geopotential height and temperature fields reveals that, despite being relatively close to each other, Lisbon and Madrid have quite different synoptic circulation anomalies associated with their respective extreme summer temperature days. SLP field reveals higher anomalies for Lisbon, but extending to a more reduced area. Extreme values in Madrid seem to require a more western location of the Azores High, embracing a greater area over Europe, even if it is not as deep as for Lisbon. Wind anomalies show clearly that Lisbon maxima occur under easterly conditions, when air flows from the central Iberian plateau, which had been previously heated. In contrast, Madrid maxima require wind from the south, transporting heat from Southern Spain and Northern Africa.

PA.31

Fog as Cause of Frequency and Seriousness of Asthmatic Attacks

B. Sc Radmila Simeva [1], B. Sc Olivija Todorovic [1], Dr. Bratka Ilijoska [2]
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[2] Service for Urgent Medical Help, Skopje

HMS of Republic of Macedonia

Bronchial asthma, as a chronic illness, is a serious medical problem in its treatment as well when its etiology must be found. In connection with that, this material explains an exoantigen which is a physical factor for its emanation, and that is fog.

Materials and methods were used from the Service for Urgent Medical Help as well as from the State Hydrometeorological Institute - Skopje.

The results of this study were acquired for a 5 years of winter periods on the territory of Skopje and its close surroundings. From the graphical illustration one can notice an increase of the number serious asthmatic attacks in days in which a high relative humidity has been registered in the air and especially in days with fog. In the winter months the Skopje basin is filled by a lake of cold air, there is a large number of days with temperature inversion and heavy fog.

An attempt was made to show the influence upon patients with asthmatic attacks in days with heavy fog have led to the following conclusion:

- The number of patients which have asthmatic attacks increases in days with heavy fog, and
- We can not influence the fog being a meteorological phenomenon, we can only give the patients advice as to how they could protect themselves from its influence.

PA.32

A Renewed Heat Hazard Index for Canada - The Work So Far and the Road Ahead

Sharon Jeffers, Abdel Maarouf, Joseph Shaykewich, and Pierre Tourigny
Meteorological Service of Canada, Environment Canada

In 2001-02, Environment Canada introduced a renewed wind chill index to take into account some of the physiological reactions that occur when the human body is exposed to cold and, thus, improve the utility of this index and its value to warn people against hazardous cold conditions. The wind chill index is based on a physical-physiological model of the face, which was validated on a group of men and women at the facilities of Defence Research and Development Canada-Toronto.

The US-National Weather Service reports that cold and heat are, in that order, the two natural factors that kill the most Americans . While heat is probably not such a killer in Canada, it seems appropriate, particularly with increased heat-island effects due to urbanization and concern of more future heat waves due to climate change, to critically review the other end of the temperature spectrum, i. e. heat indices.

In central Canada, the well-known Humidex has been used operationally since the 1970s. Humidex is based on an index (humiture) developed in the 1950s and is a simple addition, to the dry-bulb temperature in °F, of the partial pressure of water vapour in mb (hPa), with no consideration to any physiological response.

Humidex is used only in Canada; the US uses the Heat Index, which is based on Steadman's Apparent Temperature model developed in the early 1970s. Several other heat indices exist and used in other countries, each with its own limitations. This presentation will highlight some of these thermal indices.

Like the old wind chill factor, existing heat indices are based on empirical or theoretical models that were not fully validated through human physiological studies. The International Society of Biometeorology has established a special commission, endorsed by WMO, to correct this situation. Work has already begun to develop a "universal" thermal index, which would be valid at both the cold and the warm ends of the temperature spectrum. Progress to-date will be highlighted.

This presentation will also discuss the advantages of physiologically based heat indices for the protection of public health in Canada, and will conclude by suggesting some steps for the immediate future, until a universal index is fully developed.

Poster Session A

Session d’affiches A

Tuesday 3 June

lundi 3 luin

Penthouse Lobby

Niveau penthouse

Poster Session B

Session d'affiches B

Wednesday 4 June

mercredi 4 luin

Penthouse Lobby

Niveau penthouse

PB.1

CHRONOS: An Operational MSC Air Quality Numerical Forecasting Model

Richard Moffet[1] Januszh Pudykiewicz[2] Alexander Kallaur[2] Veronique Bouchet[1] Louis-Philippe Crevier[1] Alain Robichaud[1]
[1]*Air Quality Modeling Applications, Canadian Meteorological Centre*
[2]*Air Quality Research Branch, Canadian Meteorological Centre*

Since 1999, CMC has been involved in operationnal numerical Air Quality modeling. CHRONOS, the Canadian Hemispheric and Regional Ozone and NOX System, is run every night from 00UTC meteorological data from the regional CMC operational model (GEM), for a 48 hr forecast period on a domain covering North-America. A brief description of the model will be presented as well as some verifications. The model has shown skill in forecasting smog episodes related to tropospheric ozone concentration exceedences. The model has now tackled the difficult task of forecasting PM10 and PM2.5 concentrations. The operational suite and products will also be presented along with current developmental work going on in MSC.

PB.2

Development of an Industrial Plume Modelling System - I. Aerosol Evolution

S.H.Cho and D.V.Michelangeli
Dept. of Earth and Atmospheric Science, York University, Toronto

The focus of this research is to develop a reactive plume model that incorporates detailed aerosol microphysics and gas phase photochemistry in order to simulate the effects of industrial plume emissions. To do this, we use CARMA (Community Aerosol and Radiation Model for Atmospheres) developed at the NASA Ames Research Center as the time-dependent three-dimensional microphysical and radiation model. Gas phase chemistry, based on SMVGEAR II (provided by M. Jacobson) was included in CARMA. It was assumed that a Gaussian distribution could describe the plume, in current approximation. The distance from the source needed by the Gaussian model was obtained from the time step in CAMRA and the mean wind speed. The aerosols are treated as externally mixed, and the approach to treating the size distribution is sectional. The formation of aerosols includes the calculation of binary homogeneous nucleation rates of sulfuric acid vapor (H_2SO_4) with water vapor (H_2O). The model calculates the time dependent particle size distributions in an industrial region together with changes in gas phase mixing ratios of sulfuric acid vapor (H_2SO_4), assuming an initial size distribution of pre-existing particles, mainly soot, and SO_2 emissions from the industrial stacks. The model also allows for heterogeneous nucleation (adsorption) of sulfuric acid vapor on pre-existing soot particles to form new sulphate particles. Condensation, evaporation, coagulation, deposition, sedimentation and diffusion (mixing) are also included. The modification of coagulation processes present in CARMA is necessary for improved agreement of model output with measurement data. Simulating coagulation in a model is important as it is related to the prediction of aerosol number concentration (i. e. improper simulation can lead to over or under prediction). Due to this reason, the coagulation process is updated in the present model as well. Aerosol size distributions, total aerosol mass and volume, and gas phase concentrations are calculated as a function of time. Preliminary model results simulating particle formation in the plumes will be presented.

The final goal of this modeling study is to analyze the particle size distributions and chemical data obtained during field campaigns at two industrial sites organized by the Meteorological Service of Canada in the winter and summer 2000.

PB.3

Multiphase Atmospheric Chemistry Development and Integration in a Chemical Transport Model (MC2AQ)

Rafik Djouad[1], Diane V. Michelangeli[1] and Wanmin Gong[2]
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Time integration of atmospheric multiphase chemical models is a rather difficult task, especially when full 3-D models are used. This difficulty is due to both the dispersion of the chemical timescales (known as stiffness), and the dimension of the systems to be integrated (number of chemical species). In this paper we present an optimization of the multi-phase multi-droplet classes chemical box model ATMMO (ATmospheric Multiphase MOdel), using new preprocessing tools (Simplified Preprocessor for Atmospheric Chemical Kinetics, SPACK), combined with sparse solvers. The integration of such a model into the Canadian 3-D transport model MC2AQ is discussed.

PB.4

Spatial Variability of Phytoplankton Biomass and Particulate Organic Carbon over the Mackenzie Shelf/Amundsen Gulf Area

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The goal of the CASES (Canadian Arctic Shelf Exchange Study) program is to elucidate the importance of Arctic coastal ecosystems and polynyas on biogenic carbon fluxes, and the potential response of this environment to climate change. One of its hypothesis is that the variations in sea ice cover and thickness determine the levels of phytoplanktonic and microphytobenthic production of the Mackenzie Shelf and Cape Bathurst polynya. As part of this program, an exploratory mission was carried out in September-October 2002 to determine the spatial variability of total phytoplankton biomass (Chl *a*) and particulate organic carbon (POC) in the Mackenzie Shelf, the southern Beaufort Sea, the Amundsen Gulf and Franklin Bay areas. Chl *a* concentrations varied between 0 and 1.6 µg/L. Highest chl *a* values were found within the first 10 m of the water column in most sampled stations but also within the 50-60 m layer and at bottom depths for stations located more offshore and close to the Mackenzie river. In waters deeper than 78 m, chl *a* concentrations were always less than 0.1 µg/L. Phytoplankton biomass was mostly attributed to cells smaller than 5µm. POC concentrations varied between 82 and 1686 µgC/L with lowest concentrations found in the outer-shelf area while highest values were recorded close to the Mackenzie Delta. Chl *a* and POC concentrations measured during this exploratory mission are similar to those previously reported in a study which covered the western section of our sampling area. In our study, the Franklin Bay, the south-western Banks Island area, and Amundsen Gulf are clearly identified as exhibiting the greatest phytoplankton biomass for this period of the year. These preliminary results will be further discussed in reference to other studies done in the western Canadian Arctic.

PB.5

Investigation of Aerosols/Trace Elements in a Regional Chemistry-Transport-Model for the Arctic Troposphere

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During winter anthropogenic polluted air masses including gaseous and solid particles from the industrialized continents travel towards the Arctic. The main constituent of this so called Arctic haze is anthropogenic sulfate aerosol.

Model simulations using three-dimensional global atmosphere chemistry models systematically underestimate the observed concentration of sulfate in the Arctic area. This can possibly be explained by the deficits within the simulated fields of Arctic hydrological components and of near surface temperatures and winds. Regional climate models with a higher spatial resolution are able to simulate conditions of the Arctic atmosphere in a much better way.

The task of this study is to run a regional Chemistry-Transport-Model (CTM) for the Arctic troposphere for the late winter/spring months (March, April) of each year to study the spatial time

distribution of Arctic trace elements (especially sulfate which is primarily responsible for Arctic haze). Therefore it is to improve the model output by validating with observed SO2 and concentrations in the Arctic region. The regional CTM is driven by the atmospheric regional model HIRHAM and the chemical lateral forcing comes from ECHAM4. The ultimate ambition of this study is to determine the radiative forcing of Arctic haze.

PB.6

A Study of Nocturnal Boundary Layer Intermittency Using SODAR and Tethersonde Profiles

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In our effort to create protocols and regulations targeted at minimizing the rate of increase of global warming we must keep in mind the uncertainties that surround our best estimates of greenhouse gas (GHG) emission. While daytime measurement techniques are well developed, large uncertainty remains in nocturnal greenhouse gas exchange on calm nights. On such occasions, the stable nocturnal boundary layer (NBL) can be thought of as a giant chamber within which gases are trapped. Tethered blimps with associated gas collection equipment and sounding devices can be used to estimate the height of the NBL and sample greenhouse gas concentration within it repeatedly through the night. However, strongly stable conditions are not the norm and some degree of turbulent exchange can be expected. Therefore, the spatial and temporal variability of gas emission has to be accounted for. This study examines the combined use of sodar, tethersonde profiles and greenhouse gas collection for selected periods during the summer of 2002 over an agricultural surface. This poster will focus on identifying the strength and periodicity of the intermittency. The development of a nocturnal jet and NBL leakage are presented as mechanisms leading to intermittency and uncertainty in greenhouse gas collection. A better knowledge of the limitation of the NBL technique will help the scientific community to establish better estimates of greenhouse gas exchange may bring new ideas on how to improve the technique.

PB.7

Numerical Simulations of Wave-Vortex Interactions and the "Saturation" Spectrum of Density Stratified Turbulence

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It is well known that the vertical wavenumber energy spectrum throughout the stratosphere and much of the troposphere has the quasi-universal form $N^2k_z^{-3}$, where N is the Brunt-Väisälä frequency. A variety of theories can account for this spectrum, most of which assume some kind of saturation of inertia-gravity waves as the dominant physical mechanism (e. g. Dewan and Good, JGR 1986). However, stably stratified fluids possess a slow, vortical component of motion in addition to internal waves. It has recently been argued that self-similarity of the equations describing the vortical mode without waves also predicts an $N^2k_z^{-3}$ spectrum (Billant and Chomaz, Phys. Fluids 2001).

In the atmosphere, both internal waves and vortical modes coexist, interacting with one another and evolving in very different ways. For this reason, we have undertaken a program of numerical simulations aimed at examining the $N^2k_z^{-3}$ spectrum in light of the different dynamics of waves and vortical modes. As a first approximation to the problem, we consider homogeneous, density stratified turbulence without rotation. We will present results which suggest that, rather than being a universal feature of stably stratified turbulence, the shape of the k_z spectrum depends on the relative amounts of wave and vortical energy in the flow. Other differences between wavy and vortical turbulence will be presented, including horizontal wavenumber energy spectra and anisotropic energy transfer to small

scales. The varying predictions of the above- mentioned theories will be shown to have mixed success in accounting for our numerical results.

PB.8

Climatological Study of the Field of the Wind in Aerial Basin III of the Metropolitan Region of Rio De Janeiro

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This work had for objective to carry through a diagnostic study of the field of the wind in aerial basin III of the metropolitan region of Rio de Janeiro, from the climatological point of view. This study allows an evaluation of the potentialities of dispersion of atmospheric pollutants in this basin, with great population density and characterized by great concentration of industrials and highways. Simulations had been made using the model RAMS. The results had shown the importance of the process land-sea in the control of pollutants dispersion.

PB.9

Evaluation of the Internal Boundary Layer Formulae Using Various Experimental Data

S.A. Savelyev, P.A.Taylor and J.L. Walmsley

The "diffusion analogy" approach of Miyake (1965) has been chosen as a methodology to obtain expressions for Internal Boundary Layer (IBL) growth. An additional factor that influences the growth has been introduced into the analysis and parameterized by scaling considerations.

Three new formulae for neutral stability IBL heights are proposed. Their performance is compared to that of Panofsky-Dutton (1984) formula by means of published data set of measured IBL heights. An attempt was made to extend the approach to diabatic flow. Experimental data from various sources, including an old Sable Island field campaign are used to evaluate applicability of proposed assumptions.

PB.10

On Turbulence Closure Constants for Atmospheric Boundary Layer Modelling: Non-Neutral Stratification

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Constants in the turbulence closure for non-neutrally stratified atmospheric boundary layer flow are re-evaluated based on atmospheric observations. The newly proposed constants reflect the anisotropic characteristics of the atmospheric boundary layer and integrate the wall correction.

With the proposed constants for different level of the turbulence closure, sample test are conducted for simple, one-dimensional atmospheric boundary-layer flow with non neutral stratification. Comparison of model results with Freedman and Jacobson's model and some observational data show promise for improving boundary-layer predictions.

PB .11

Three-Dimensional Lagrangian Simulation of Suspended Particles in the Neutrally Stratified Surface Boundary Layer

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A three-dimensional (3-D) inertial particle - Lagrangian stochastic model for heavy particles in turbulent flows has been constructed. In this model, particle velocities are computed by adopting a nonlinear drag law, while fluid velocities are calculated in the vicinity of a particle satisfying a 3-D Langevin equation. Our model results have shown that the inclusion of the horizontal fluid velocity fluctuations and a nonlinear drag law have great impact on the statistics of both fluid and particles when compared with our one-dimensional (1-D) model with a linear drag law. Model results have been compared with published field data of heavy snow particles. It can be shown that the particle concentration predicted from our 3-D model has better agreement with field measurement when compared with our 1-D model. We have also investigated the value of ß, the ratio of eddy diffusivity to eddy viscosity for heavy particles with our 3-D model. Our model results show that ß increases slightly near the surface, while decreases slightly in most of the suspension region when compared with the 1-D model. The use of a non-linear drag law is closer in concept to Businger's 1965 theory than our earlier 1-D model but there are still significant differences.

PB.12

An Inertial-Dissipation Technique for Non-Isotropic Turbulence

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Two 614 kHz acoustic Doppler current profilers (ADCPs) were deployed through land-fast ice in the Canadian Arctic Archipelago in May 2002. One of the instruments used a high resolution, high accuracy, but low penetration "mode 11". Both instruments recorded the velocity components. Vertical velocities were corrected for beam spreading following a recent technique developed by Marsden and Ingram (2002). Turbulence parameters for hourly ensembles having mean flows > 0.1 m s^{-1}, were examined. Reynolds stress as a function of depth was calculated directly and using the variances of beam velocities as proposed by Lohrmann *et al*. (1990). It was found that directly calculated Reynolds stresses, corrected for low-frequency variability attributed to internal waves, produced the most consistent results. Data exhibited a decrease in mean flow and increase in Reynolds stress approaching the ice-water interface. The wall is shown to be hydro-dynamically smooth and the turbulence non-isotropic. A linear model was used to determine eddy viscosity. Overall, values were low (0.5 - 5.0 x 10^{-3} m^2 s^{-1}) and over 99% were > 0, indicating a general down gradient momentum flux. A similar linear model of the shear, valid for neutral stability, was in agreement with theory only as a lower bound, suggesting that stability effects (not measured) were important in the near Ekman layer. A -5/3 region was identified in the velocity spectra. The vertical spectral power densities were about two orders of magnitude less than those of the longitudinal velocity spectra, confirming the non-isotropic nature of the turbulence. The inertial dissipation method proposed by McPhee (1994) was verified. Directly measured turbulent production was highly correlated with surrogate estimates of dissipation based on the geometric mean of the vertical and horizontal longitudinal velocity spectra. Reynolds stresses were directly compared to eddy viscosities. The implied mixing lengths, much smaller than predicted for isotropic turbulence, were found in this low energy data set. A method is demonstrated, based on the turbulent kinetic energy budget, that allows for an estimate of the eddy viscosity, that is independent of shear and a mixing length hypothesis.

PB.13

Global Environmental Multiscale Temperature as a Proxy Indicator of the Thermodynamic Evolution of First-Year Sea Ice

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Ice numerals determined by the Arctic Ice Regime Shipping System (AIRSS) are used for vessels operating in Canadian waters taking into account the ice regime (i. e. distribution and mix of ice types), the class of the vessel and the decay of the ice. However, estimates of the decay state of sea ice incorporated into the ice numeral calculation are often not possible or made from infrequent visual

observations that cannot be used for longer-term ship navigation. The thermodynamic evolution of the backscatter from time series synthetic aperture radar (SAR) has been linked to the decay state of first year sea ice but it has yet to be used operationally due to image size and acquisition demands. In order to over come this, the backscatter derived from RADARSAT-1 was spatially forced with Global Environmental Multiscale (GEM) derived temperatures in the form of accumulated melting degree days (MDD) over the Western Arctic. This resulted in an operationally efficient means of estimating sea ice decay of first year ice. Ice decay was partitioned into three ablation states: melt onset, ponding and drainage based on accumulated MDD. The implications of this approach are that it provides improved AIRSS ice numeral values that may contain unrepresentative estimates of ice decay of a particular ice regime. In terms of ship navigation, this implies that more efficient routes can be plotted not to mention provides a robust ice decay measure for long-range forecasting.

PB.14
Validation of a Coupled Atmosphere-Ice-Ocean Model
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The Canadian Ice Service in partnership with the Institute of Ocean Science (IOS), the Canadian Center for Climate Modeling and Analysis (CCCMA), and the Bedford Institute of Oceanography (BIO) has undertaken a project to predict the evolution of Canadian sea ice conditions over the next 25 years. Coarse GCM results will be refined down to a regional scale using a higher resolution coupled atmosphere-ice-ocean model. In this poster, the ability of the higher resolution model to reproduce sea ice conditions when forced with observations from the NCEP Reanalysis is investigated. Model generated sea ice is compared to the CIS digital database, submarine data, and other sea ice data sets. Using SVD analysis, atmosphere-ice interactions in the model are also investigated.

PB.15
Canadian Long Range Ice Forecasting (CLIF) in Hudson Bay
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The Canadian Ice Service has established a Canadian Long-Range Ice Forecasting (CLIF) research group to address the need for 3-12 month and 1-5 year sea ice forecasts. Initial results from CLIF for Hudson Bay are presented. EOF analysis is used to help establish a climatology for the region and to develop ice indices to represent the shipping season. Correlations and composite analysis are used to elucidate the relationship between summer ice conditions in Hudson Bay and pre-season Northern Hemisphere sea level pressure, sea surface temperature and 500 mb heights.

PB.16
Ice Breakup Visual and Micro Wave Observation on Great Slave Lake and its Relationship to Local Air Temperatures
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The timing of lake ice breakup is an integrated index of significance to global geophysical systems because of its property of being able to be predicted by, a simple meteorological parameter, station temperature. The calendar date of ice breakup on Great Slave Lake has been recorded since 1953 using visual (1953 - 1990) and satellite microwave (1979 - 1999) observations. A bimodal relationship between breakup and air temperatures exists at an integration time of 31 days, with the breakup date being related not only to air temperature during the thaw (April) but also to that

prevailing during the time of ice formation (February) when the temperatures are the lowest. When the air temperature and the AO (Arctic Oscillation) are regressed against the ice breakup dates using the visual observations an R squared value 0.39 is obtained. However, when the air temperature and the AO are regressed against the ice breakup dates using the satellite observations an R squared value of 0.89 is obtained. This gives an indication of the increased precision that can be obtained when the observer based ice breakup is supplanted by a satellite based system. While the correlation with the April temperatures are greatest, those with the February temperatures are also significant. Because air temperatures in the NWT contain a strong AO signal so does the Great Slave Lake breakup date.

PB.17

Modélisation mathématique d'un problème lié à la glaciologie

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Les équations aux dérivées partielles (EDP) linéaires et non linéaires constituent un vaste ensemble très actif qui s'est développé considérablement dans la période récente. Par nature, ce domaine présente de multiples interactions avec plusieurs autres champs des mathématiques et il est très utilisé dans la modélisation de phénomènes relevant d'autres disciplines comme la physique, la chimie, la biologie, l'économie, l'imagerie, etc. D'autre part les domaines d'application ne cessent de s'élargir, allant des problèmes de la chimie, comme ceux de la combustion ou de la cinétique des réactions, à certains aspects d'environnement, glaciologie et autres. Plusieurs autres champs d'applications s'ouvrent aux problèmes de turbulence ou ceux liés aux interactions entre fluides et structure. Ce travail s'inscrit dans une thématique faisant appel à la modélisation mathématique à travers les équations aux dérivées partielles de certains problèmes liés à la glaciologie. En fait, on essaie d'interpréter ce phénomène au moyen d'une formulation et d'une résolution d'un problème elliptique non linéaire faisant intervenir des opérateurs qui ont un aspect purement physique, spécialement l'opérateur p-Laplacien. On s'intéresse plus précisément aux solutions admissibles positives qui interprète une certaine vitesse d'écoulement ou densité du glacier, par suite on cherche à les régulariser pour bien localiser le glacier, en fait, le problème modèle n'est qu'un prolongement de la fameuse équation de Schrödinger.

PB.18

On the Integration of Sea Ice Information into ECDIS

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An Electronic Chart Display and Information System (ECDIS) is a computerized navigation system, consisting mainly of a computer processor and display, a standardized database, and navigation sensors. ECDIS is not only capable of displaying the navigation-related information in real-time but also supporting other advanced functions, such as route planning, route monitoring and automatic alarms. In ice-infested waters, the use of ECDIS as a standalone information system would not provide sufficient information for safe navigation. Safe and efficient marine navigation in ice-infested waters require comprehensive and timely information on the sea ice conditions. To enhance the safety of marine navigation in ice-infested waters, the Canadian Ice Service (CIS) uses remote sensing techniques to extract the sea ice information in the form of daily ice charts. The availability of the ice charts enables the mariners to make critical decisions regarding the selection of the best possible navigation routes.

While highly useful in providing the mariners with comprehensive ice information, ice charts may not fulfill the requirements for safe and efficient marine navigation, even if they are used side-by-side with ECDIS. Canadian research funded by CRESTECH now underway at Ryerson University and the University of New Brunswick proposes that, in ice-infested waters, an integrated navigation chart system may be developed which integrates vital ice information into an ECDIS in a formal, standards-based manner.

This paper discusses a production approach demonstrating how Canadian ice chart and standardized ice object attribute data could be integrated into an ECDIS using three commercially available software packages. A prototype production flowchart is explained, and both results and challenges of the proposed approach are described in detail.

PB.19

Relating Wind Velocity, Sea Ice Melt Pond Morphology, and Melt Pond Surface Roughness over Arctic First-Year Sea Ice to Observed RADARSAT-1 Standard Beam Mode Backscatter

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Surface melt ponds significantly reduce the albedo of snow-covered sea ice, thereby dominating the surface radiation balance through enhanced absorption of shortwave radiation. Despite the significance of melt ponds to the ocean-sea-ice atmosphere (OSA) interface, as well as the decay-rate of sea ice, the spring/summer melt pond season is not well accounted-for in mass balance, heat flux, and modeling studies. Recent research has utilized time series RADARSAT and ERS synthetic aperture radar (SAR) backscattering coefficients to detect the onset of melt ponds and determine their fractional coverage [e. g., Comiso and Kwok, 1996; Jeffries et al., 1997; Yackel et al., 2000]. Uncertainties in the interpretation of SAR data during this time period arise from the fact that melt ponds are dynamic and sub-resolution of current space borne platforms.

This paper addresses the ambiguities in observed RADARSAT-1 SAR (Standard Beam mode) backscatter during the 2002 melt pond season over first-year sea ice in the Canadian Arctic Archipelago. Microwave theory indicates that surface roughness becomes the predominant scattering mechanism when freshwater ponds form on the sea ice surface from the melting of meteoric snow. Wind then becomes the dominant forcing mechanism on the variability and magnitude of surface roughness on melt ponds. The sinusoidal component of the surface wave spectrum of wind-generated melt pond capillary waves agrees well with the preconditions of Bragg resonance scattering, though all conditions for Bragg scattering may not be rigorously met within the ensemble of scatterers comprising a SAR footprint. Given a wind event, the coherent scatter reinforcement from small, sub-scale resolution, wind-roughened melt pond patches will dominate the returned power to the SAR antenna. For multi-look Standard Beam RADARSAT-1 SAR imagery, this reinforced scattering will be smeared due to azimuth image shift caused by the movement of surface waves during scene integration.

Preliminary results from the Collaborative Interdisciplinary Cryospheric Experiment (C-ICE) 2001 field campaign (75° N, 97° W) yielded a multiple R^2 of 0.81 for melt pond surface roughness (RMS height and correlation length) as a function of wind speed and fetch length. For C-ICE 2002 a total of 81 digital video surface roughness profiles of melt ponds were captured under a variety of wind conditions and surface morphologies over land fast first-year sea ice. These data are complemented by a suite of digital photography and aerial video of varying melt pond fractions and morphologies throughout the melt pond season, as well as coincident meteorological data. Data from C-ICE 2002 will be integrated into a modified 2-D Bragg scattering model and used to predict microwave backscattering at 5.3 GHz (i. e., RADARSAT-1) for a melt ponded sea ice scene. Results will be compared to observed RADARSAT-1 backscatter from coincident Standard Beam mode scenes from June 16 to July 15, 2002.

PB.20

Weather Prior to Major Avalanche Episodes in Western Canada during the Winter 2002-03

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Unusually dangerous avalanche conditions prevailed this winter in southwestern Canada despite a shallow winter snowpack related to a moderate El Niño event. Twenty-six lives were claimed by avalanches in western Canada by early April 2003, which is a fatality rate more than double the normal. This is in part due to the greater number of winter recreationalists using the back country, but also due to a highly sensitive snowpack which developed in winter 2002/03. In this paper, we examine the critical weather conditions and forecasts preceding major avalanche episodes. The aim of this paper is to improve our understanding of precursory weather leading to exceptionally dangerous avalanche conditions and allow avalanche forecasters to predict these events in the future.

The region examined in the this paper focuses on southeastern British Columbia where most of the accidents occurred - but all regions of BC and nearby Alberta are evaluated. Special emphasis is placed on a buried ice layer from November 2002, which was overlain by several unusually weak zones of surface hoar crystals. Critical weak zones of hoar crystals developed in thin surface layers and near bedrock during cold clear periods. The clear nights were caused by a persistent high pressure ridge which is common during early winter El Niño weather patterns. Occasional break-downs of this ridge allowed several pineapple express-type storms to bring brief - but dramatic - wet episodes to the mountains. These produced heavy snowfalls followed by rain to the highest elevations, followed by more clear cold nights - which topped each storm sequence with another surface hoar frost layer. By mid March the El Niño pattern had eased, allowing a moist southwesterly flow to rapidly rebuild snow packs to nearly normal levels by the end of March 2003. This of course was on top of previously identified weaknesses in the snowpack.

This paper aims to summarize the synoptic conditions which led to a winter with unusually severe avalanche events that closed highways and produced many fatalities. Our goal is to help reduce deaths in the future and keep transportation corridors open through better communication of meteorological conditions which led to these events.

PB.21
Etude de la stabilité de la fréquence principale d'une équation énergétique
Abdelouahed El Khalil
District urbain chrarda Ain Kadous, Maroc

Lorsque l'exposant rhéologique **p** change dans l'intervalle [1, +infini], le contexte d'applications physiques gouverné par l'opérateur **p**-Laplacien change aussi. Par exemples: les fluides non Newtoniens (les fluides dilatants ont 2<**p** et les pseudo-plastiques ont 1<**p**<2), les problèmes de réactions et de diffusions, l'élasticité non linéaire et la glaciologie (**p**=4/3). Ainsi, on va étudier dans ce papier la dépendance de l'équation énergétique faisant intervenir le **p**-Laplacien et sa fréquence principale par rapport à **p**, de plus, on interprète qualitativement dans un sens convenable l'équation limite lorsque p tend vers l'infini

PB.22
An Envelope Rossby Soliton Model for Block-Eddy Interaction: Impact of Inhomogeneous Baroclinicity
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In this paper, the importance of the inhomogeneous baroclinicity upstream in the onset of isolated vortex pair block associated with synoptic-scale eddies is investigated theoretically in a two-layer model based upon the envelope Rossby soliton concept. The vertical shear of basic state wind is assumed to vary slowly in the zonal direction so as to permit the representation of zonally localized regions of high baroclinicity. It is found that the spatial resonance condition between an incipient dipole and the eddy forcing arising from preexisting synoptic-scale eddies is more easily met in the baroclinic case than the barotropic case and most easily satisfied at the maximum point of high baroclinicity. The strength of isolated barotropic vortex pair block excited by the synoptic eddies is enhanced by the high baroclinicity upstream and its lifetime is prolonged if the position of the

maximum baroclinicity is about pi (5740km) ~ pi/2 (2870km) upstream of the initial weak dipole prior to the onset of vortex pair block. In this process, the high baroclinicity tends to make the intensified barotropic vortex pair structure shift more westward than the barotropic case, but the baroclinic component of vortex pair block remains always immoveable. During the decay stage of coherent structure, the high baroclinicity upstream will promote the development of the weather systems downstream of vortex pair block, which becomes particularly noticeable for the forcing of unstable synoptic-scale eddies. On the other hand, the strong meridional eddy heat fluxes are found to precede the full establishment of vortex pair block. Thus, it is suggested that the high baroclinicity upstream is a favourable environment for the onset of vortex pair block besides exciting synoptic-scale eddies.

PB.23

Mesospheric Temperature Inversions in a Middle Atmosphere General Circulation Model: their Spatial and Temporal Variability and Origin

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Temperature inversions in the mesosphere are frequently observed by ground-based lidars and by satellites. A number of different mechanisms, ranging from small-scale gravity waves to large-scale disturbances such as tides and planetary waves, have been proposed to explain their origin. In this presentation a middle atmosphere general circulation model extending from the Earth's surface to the middle thermosphere is used to investigate mesospheric temperature inversions. We first compare the frequency and strength of the simulated inversions to general characteristics of the observations from ground-based and satellite data, and then go on to explain what causes them in the model.

PB.24

MLT observations using SATI (Spectral Airglow Temperature Imager)

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The MLT (Mesosphere and Lower Thermosphere) region is known to be dynamically complex, primarily due to the tides and gravity waves that propagate upward from below. The emission rate and temperature fluctuations related to these waves are observed using a ground-based optical instrument, called SATI (Spectral Airglow Temperature Imager). The SATI instrument was installed and has been in routine operation at Resolute Bay (74.68 N, 94.90 W) since November 2001. By spectrally monitoring the O2 (0-1) atmospheric band from ~ 94 km and OH (6-2) Meinel band nightglow from ~ 87 km, SATI measures the rotational temperatures and the emission rates of the terrestrial nightglows. From the analysis of 2001/2002 winter season data, dominant and coherent 4-hr oscillations were observed in both the O2 and OH airglow emission rates and rotational temperatures (Won et al., GRL in press). The 4-hour oscillation has a shorter period than other major waves that have been reported previously in lower or even in high latitudes. The multi-emission observations also allow us to examine the vertical structure of the wave. In addition, the mesospheric cooling related to the sudden stratospheric warming is compared with stratospheric assimilated data. During these events, polar stratospheric temperatures show a rapid increase in a few days, and at the same time a cooling at the mesosphere is observed. Occurrences of major stratospheric warming in northern hemisphere are usually observed in January and February. However, the mesospheric cooling observed by SATI appeared at the end of December 2001.

PB.25

Temperatures in the Mesopause: Detecting Long Term-Trends in Hydroxyl Airglow Rotational Temperatures from Davis Station, Antarctica

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Tropospheric warming, due to increased greenhouse gas concentrations, is expected to be associated with enhanced cooling in the upper stratosphere and mesosphere. Modelling studies predict a maximum cooling response in the high latitude mesosphere. Nocturnal hydroxyl airglow emissions originate from a layer about 8 km thick, centred near the mesopause at 87 km altitude. Ground-based spectroscopic observations of these emissions can be used to infer the temperature of the emitting region.

The Space and Atmospheric Sciences group at the Australian Antarctic Division operates a Czerny-Turner scanning spectrometer at Davis station, Antarctica (68.6°S, 78.0°E) to routinely scan the hydroxyl (6-2) band. To date, 10 years of spectra have been collected in an ongoing monitoring program.

From a detailed investigation of the spectra and background contaminants, an innovative analysis technique has been developed to account for satellite line contributions, auroral contamination, solar Fraunhofer absorption and the different lambda doubling widths of emission lines to optimise the rotational temperature determinations for climate change studies.

An assessment of the long-term temperature change is made using a multivariate fit analysis, applied to seasonally de-trended nightly average temperatures. The multivariate fit assumes a linear long-term trend and solar cycle dependence. Results of the trend assessment are presented.

A visible impact of cooling temperatures near the mesopause is the increase in occurrence rates of noctilucent clouds (NLC). Such clouds have been observed at Davis in recent years. An NLC example with concurrent hydroxyl temperature measurements is also presented.

PB.26

Mid-Latitude Stratospheric NO_2 during Summer Time: Comparison of Measurements from Three MANTRA Balloon Campaigns, Climatology, and the Canadian Middle Atmosphere Model

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Observations of nitrogen species are of primary importance in studies of ozone chemistry and climate change. The stratospheric circulation and the distribution of O_3 control the transport of long-lived greenhouse gases to regions of photochemical loss as well as the penetration of solar UV into the atmosphere. At the same time, many of these gases supply ozone-depleting radicals (e. g., NOx) to the stratosphere, providing a feedback between the gas and its loss rate. Middle Atmospheric Nitrogen TRend Assessment (MANTRA) is a set of balloon campaigns aimed at investigating the changing chemical balance of the mid-latitude stratosphere. This paper reports on the results from three MANTRA campaigns which involved the launch of large balloons from Vanscoy, Saskatchewan, Canada (52°N, 107°W) on August 24 th 1998, August 29 th 2000, and September 3 rd 2002.

From the balloon, vertical distributions of O_3 and NO_2 were measured by UV-visible grating spectrometers, and by a SAOZ instrument included in the 2002 campaign, all in solar occultation. In addition, ozone profiles were obtained from ozonesondes launched daily through the campaigns. As part of the campaigns, another UV-visible spectrometer was operated on the ground measuring scattered sunlight in a zenith-sky configuration. O3 and NO2 slant column densities were extracted

from those measurements as a function of solar zenith angle, and NO_2 vertical profiles were retrieved from the NO2 slant column values. In this paper we compare the retrieved NO_2 profiles from the three MANTRA campaigns with a climatology based on observations from satellites, other balloons, and a set of NDSC sites. The results are also compared with output from the Canadian Middle Atmosphere Model (CMAM), a fully interactive chemistry-climate model. Late summer is an ideal time to make such a comparison because of low dynamical variability in the stratosphere.

PB.27

Retrieval of Stratospheric Ozone and Nitrogen Dioxide Profiles from Odin/OSIRIS Limb-Scatter Measurements

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The Optical Spectrograph and InfraRed Imager System (OSIRIS) is a Canadian instrument on the Swedish/Canadian/Finnish/French Odin satellite launched on 20 February 2001. OSIRIS consists of (i) a UV-visible imaging spectrograph designed to measure the spectrum of sunlight scattered by the limb of the atmosphere in the spectral range 280 nm to 800 nm at a resolution of 1 nm, and (ii) a 3-channel IR imager designed to measure atmospheric airglow emissions near 1270 nm and 1530 nm in a limb-viewing tomographic mode. The scattered sunlight spectra are used to determine vertical profiles of minor stratospheric constituents such as ozone, NO2, BrO and aerosols and the IR images are used to provide high resolution 3-D distributions of ozone in the mesosphere.

Vertical profiles of ozone and NO2 dioxide density derived from Odin/OSIRIS measurements of limb-scattered radiance spectrum profiles are presented. Ozone profiles are inferred using a method based on the analysis of normalized and paired limb-radiance profiles at a set of wavelengths covering the O3 Huggins- and Chappuis-bands, and Differential Optical Absorption Spectroscopy (DOAS) is used to retrieve O3 and NO2 profiles. Both techniques incorporate the pseudo-spherical multiple scattering radiative transfer model LIMBTRAN and the Optimal Estimation (OE) approach.

PB.28

Dynamical Balances in the Tropical Middle Atmosphere

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The geostrophic and other small-Rossby-number balance relations (e. g. linear balance) are useful ways of characterizing large-scale motion in the extratropics, and provide constraints between the observed wind and mass (or temperature) fields assimilated into numerical models. This is especially important in the middle atmosphere, due to the relative paucity of wind measurements. By and large, the extratropical wind fields in the lower stratosphere produced thereby through assimilation are found to be quite good, and have been used in many applications such as quantification of ozone loss. However, no such balance constraints are imposed in the tropics, because the Rossby number diverges, and what measurements we have suggest that assimilated winds are of very poor quality in the tropics. It is nevertheless the case that we expect, on theoretical grounds, other kinds of balance relations to hold between the wind and mass fields; for example small-Froude-number balance, or a semi-geostrophic balance whereby only the zonal wind component is in geostrophic balance (as in equatorial Kelvin waves). Thus, it is interesting to consider whether information on the tropical wind field could be obtained from the mass field.

In order to address this question, we assess the degree to which various balances hold in the zonal band 30S-30N in the stratosphere of the Canadian Middle Atmosphere Model. The analysis is

focussed on the stratosphere since upward-propagating gravity waves reach sufficient amplitude to preclude balance above the stratopause. The hope is that if balance relations can be identified, they could be implemented in stratospheric assimilation. We also examine whether the lack of any balance constraint in existing stratospheric assimilation leads to spurious unbalanced structures in the resulting analyses.

PB.29

The Influence of Assimilating Dynamical Variables on Ozone in the Canadian Middle Atmosphere Model

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The Canadian Middle Atmosphere Model (CMAM) is a three-dimensional coupled chemistry general circulation model which has been used as the basis for a climate assimilation study. Up to this point in time, only dynamical variables and humidity have been assimilated into the model runs, but as a first step to assimilating chemical variables we have considered how the model ozone field is affected by the assimilation of only the dynamical variables.

In this talk I will present results from an assimilation run using observational data from January 2002 and highlight the impact that assimilating dynamical variables has on the ozone field. Various runs are performed using different initializations of the ozone field at the start of the run. These include using raw model data, scaling the model ozone to reflect more accurately the column ozone amounts of January 2002, and using correlations between PV and observed ozone to obtain a three-dimensional initialisation field. The results show that even though only dynamical variables are assimilated a reasonably accurate representation of the ozone field can be obtained after one month of assimilation. The accuracy of the resulting ozone field obtained by the different initialisation techniques will be discussed. The use of different ozone initialisations may also lead to a better estimation of the relative contributions of model and initial state error on the updated ozone fields.

PB.30

Quantifying the Tropopause Mixing Barrier in the Canadian Middle Atmosphere Model

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Mixing barriers in the atmosphere play an important role in shaping the large-scale dynamical circulation, and greatly affect the transport of chemical species. While some success has been achieved in identifying the edge of the tropical pipe and the wintertime polar vortex barrier, finding the location of the tropopause mixing barrier has proven to be much more elusive. In this study, various methods are applied to identify the tropopause mixing barrier in the Canadian Middle Atmosphere Model, a three-dimensional coupled chemistry GCM. A GCM is used partly to provide a dynamically self-consistent data set, and partly because it is an important exercise in itself to assess the extent to which such models represent the tropopause mixing barrier. The methods studied include Nakamura's effective diffusivity, age of air, PDFs of chemical species, seasonal evolution of ozone, and investigating the balance between radiative heating and cooling. In addition to quantifying the tropopause mixing barrier in the model, comparison of the different methods sheds light on their commonalities and differences.

PB.31

Meteorological Data Transfers via Internet: A vision

Luc Vescovi, Lam Khanh Hung and Richard Laurence
Ouranos-SMC

In the current technological world, one can already envisage Internet users accessing directly, by means of a friendly GIS-web based interface, metadata describing the stations information, the available climate data. Also, nowadays identifying what data the user wishes to obtain and downloading these data in the most suitable formats (numeric data, analyzed maps, etc.) without considering either where the information lies or the specific formats used by the data providers, are more and more user-friendly and interactive actions.

The implementation of such a vision presupposes the active collaboration of many partners and the resolution of several technological and managerial challenges. As a matter of fact in Quebec the principal producers of meteorological data have agreed to share their data between themselves in real time (Réseau météorologique coopératif du Québec RMCQ). Many technical and management issues related to data sharing were raised in that context. RMCQ managers have begun discussions on the potential widening of the distribution of their data to third parties and on access to historical data and metadata.

This paper aims discuss in a technology transfer context which model of data access and distribution is best adapted to the Quebec reality, how the transfer towards an easy access to the data can be made and what role Ouranos (a new Quebec-Canada consortium on regional climatology and adaptation to climate changes) and its Historical Data Component could play. A particular attention will be paid to short term implementation issues. Finally, this paper will discuss the capabilities and the user friendliness of these tools for OURANOS and data users.

PB.32
Lightning Forecast in SCRIBE

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A lightning forecasting system has been developed in the context of the SCRIBE Nowcasting Project. The goal of the system is to estimate the probability that lightning will occur in the vicinity of a point of interest, during the next one to six hours. This probability will then be used to update the objective or manually edited weather element forecasts to take into account impending thunderstorm occurrences or non occurrences. The system works by first analyzing the lightning activity over the past hour over a 100 x 100 km grid centered on the target station, at a 5 km horizontal resolution. Dividing the hour into three twenty minute periods, and then evaluating the motion of the most northern, southern, eastern and western cells with observed lightning strikes between these three periods yields an average motion vector. This vector is then applied to the analyzed data and each grid cell with observed lightning strikes is projected into the future, without taking into account the increase or decrease over time of the number of lightning strikes in each the 400 cells of the 100 X 100 km grid. For each forecast hour, the distance between the forecast data and the central target station is measured along with the direction of motion. A set of rules is then applied to calculate the probability that the target point of interest will be affected by lightning. These lightning probabilities are diagnosed from the displacement of the cells with observed lightning strikes and is inversely proportional to the distance to the target station.

A verification system has been developed to evaluate the forecasts. The system works by comparing the forecast position of the cells with forecast lightning strikes for each of the six forecast hours to the data analyzed at the corresponding times. The number of hits, misses, and false alarms are estimated for each forecast hour, along with the probability of detection. Verification is done at different levels of "tolerance" with respect to the position of the observed cells. The tolerance is equivalent to allowing an error margin of 5 or 10 km on the position of the grid cells with observed strikes with respect to the cells with forecast lightning strikes. Brier score is used to assess the skill of the lightning strike probability forecasts.

The system shows the most skill in the very short term with marginal skill beyond two to three hour projection time. It also shows higher probability of detection and fewer misses when the verification is carried over a 20 x 20 km subgrid centered on the target station.

The oral presentation will describe the lightning strike forecast algorithm together with verification results that show the skill of the system over the full projection time form one to six hours.

PB.33
Prévisions objectives de temps convectif à partir des sorties de gem 24 km /Objective Forecasts of Convective Weather Based on Direct Outputs from GEM 24 Km
D. Bachand
Centre Météorologique Canadien / Canadian Meteorological Centre

On a produit pour la première fois au CMC à l'été 2002 des cartes objectives de temps convectif montrant les zones potentielles d'orages ordinaires et d'orages violents pour des périodes de prévision données. Nous présenterons les prédicteurs utilisés pour produire ces cartes de même que les résultats de vérification des zones prévues à partir du modèle régional GEM 24 km.

For the first time at CMC, we have been producing during the summer of 2002 objective charts of convective weather showing potential areas of regular as well as of severe thunderstorms for given forecast periods. We will show the predictors used to produce these charts and some verification results of the forecast areas based on regional GEM 24 km model.

PB.34
Another Update on Updateable MOS
Laurence J. Wilson and Marcel Vallée
Recherche en Prévision Numérique, Dorval, Quebec

UMOS goes global! Using a data archive of global model data that was started at the same time as the Regional GEM model UMOS archive, we have been able to produce UMOS forecast equations for about 200 Canadian stations for three hourly spot temperatures out to 6 days. Examination of some individual cases has shown some spectacular successes of these forecasts, for example, temperatures forecast correctly within one degree C six days ahead.

We have carried out objective summary verification of the UMOS global temperature forecasts; these results indicate a substantial improvement with respect to the existing perfect prog based operational temperature forecasts at all forecast ranges. As a result, it is planned to implement the new UMOS temperature forecasts at CMC.

UMOS forecasts based on the regional model output are operational for temperature, POP (6h) and wind. These forecasts are used to drive the inputs to SCRIBE. In addition to the development of UMOS-global, we have been extending the predictands for UMOS-regional to categorical variables. Using multiple discriminant analysis, we have produced forecast equations for cloud amount in 4 categories, and are planning to develop equations for probability of precipitation amount. Results for cloud amount forecasts also show improvements with respect to the operational cloud amount guidance.

The presentation will include both results from the GEM-global temperatures and from the GEM-regional cloud amount forecasts.

PB.35
On Predicting Maximum Snowfall Amounts
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Department of Earth and Atmospheric Sciences, University of Alberta

We present a tool to assist in decision of issuing a heavy snowfall warning for the Mackenzie River Basin (MRB). Snowfall in excess of 10 cm per day in the MRB is associated with large-scale ascent within a wave cyclone and the maximum amount of snowfall depends on the maximum amount of vapour available for sublimation. Using the principle of conserving water substance, the maximum snowfall amount is related to the saturated vapour mixing ratio at cloud base and cloud top levels. The inherent uncertainties of the input data allows for numerical approximations that lead to a linear relationship between maximum snowfall and cloud base temperature. To test the validity of the linear snowfall-temperature relationship, an analysis was made of the correlation of 24 h snowfall measurements with temperature observations from upwind soundings. The data set covered all of Alberta (with the exception of the mountainous west) for the period October 1990 to April 1993. The data confirm that the sow amounts depend roughly linearly on the 850 mb temperature with a correlation coefficient of 0.62. The implications of this finding on making a predicting heavy snowfall are discussed.

PB.36
SCRIBE/marine
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Development Branch, Canadian Meteorological Centre

The SCRIBE system has been expanded to handle all marine forecasts under the responsibility of the Meteorological Service of Canada (MSC). The SCRIBE/marine product generator has been made compliant to the Standard Operating Procedures of the MSC. SCRIBE/marine is using the same framework as the public counterpart with a set of rules specific to the marine milieu, putting emphasis on wind and wave forecasting.

The content of the SCRIBE matrices have been revised to incorporate guidance more suitable to the marine environment especially with regards to wind and waves. An algorithm has been developed to produce first guess sea state for region outside of the wave model domain and some studies have been done to improve wind guidance. SCRIBE/marine is based on an open architecture framework where external models, such as a wave model, can be launched from SCRIBE data and the output of which can be ingested back into SCRIBE. This set-up is used particularly at the Québec Region.

The interface has been modified to include all the relevant parameters related to marine forecasts. In addition, new functionality has been added to allow forecasters to manipulate the weather elements either with the regular SCRIBE graphical user interface or with a code editor based on Atlantic Region's COMAR program.

The functionality of SCRIBE/marine will be presented at the oral presentation and examples of marine forecast products will be shown.

PB.37
Adaptation of the Canadian Updateable Model Output Statistics System to the Forecast of Marine Winds on the Great Lakes - Results
Syd Peel , Laurence J. Wilson, and Marcel Vallee
Meteorological Research Branch, Meteorological Service of Canada

The Canadian Updateable Model Output Statistics (UMOS) system has been developed and implemented operationally by the Canadian Meteorological Centre (CMC) and the Meteorological Research Branch of the Meteorological Service of Canada (MSC). The operational version of UMOS produces forecasts for a number of meteorological parameters, including the surface wind, at more than 200 sites across Canada, and is a key component of the model guidance supplied to forecast production offices throughout the country. Faced with the task of refining the wind forecasts generated by the Global Environmental Multiscale (GEM) model for the Great Lakes, we therefore decided to investigate the feasibility of implementing UMOS in this role.

In this paper we examine the pertinent observational and model data available for the regression of the surface winds observed on the Great Lakes onto predictors obtained from a numerical weather prediction model. A brief survey is undertaken of possible approaches to the regression, highlighting those characterisitics of particular relevance to the problem at hand. This sets the background for our decision to adopt UMOS for the solution, and a brief description of the UMOS system itself is given, along with those modifications introduced in its application to the forecast of the marine winds on the Great Lakes.

The forecasts obtained from this application of UMOS have been tested on independent observational samples, and compared against direct model output from the operational GEM model integrated at CMC. Comparisons have also been made against the perfect prog forecast for the Great Lakes produced by the National Weather Service of the United States, and against the official marine forecast issued for the Great Lakes by the forecasters of the Ontario Region of Environment Canada. The comparison against the official marine forecast in particular posed some significant challenges, and the methods and compromises adopted in order to effect this comparison, along with its limitations, are discussed.

Finally, the relative performance of UMOS against these forecast systems is presented. In addition to the more familiar measures-oriented summary scores such as the probability of detection and false alarm ratio, more detailed descriptions afforded by distributions-oriented outputs are also examined. Some conclusions drawn from these results are offered, along with possible avenues for future work.

PB.38

Tornado Outbreaks in Ohio, Storms inSouthern Ontario on Nov 10/11, 2002.

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At noon on Nov. 10, 2002, tornadic supercells began to form along a squall line from Ohio to Alabama in the eastern United States. The outbreak lasted more than sixteen hours. According to statistics from the NOAA Storm Prediction Center, there were 91 reports of tornadoes, 327 reports of wind damage and 190 reports of large hail in this event. Thirty people died and about 224 people were injured in this event. Some of the most serious events, including 18 tornado reports, were in Ohio, just south of Lake Erie. Stormy weather occurred just across the lake in Southern Ontario on Nov. 10/11, but not even one report of severe weather was received, and certainly no tornadoes were reported north of the lake.

Evaluation of upper air soundings and surface data plus the use of composite charts based on the Miller techniques for evaluating severe storm potential help explain why Southern Ontario was spared the worst of this late summer-like storm.

PB.39

A Report Card on the Precipitation Sensors in the Reference Climate Stations (RCS) and Surface Weather (SWX) Networks

Yves Durocher
Surface Weather, Climate and Marine networks, Meteorological Service of Canada

Environment Canada's evaluation of the precipitation sensors lead to the selection of two all weather precipitation sensors for use in the Reference Climate Stations (RCS) network and the surface weather (SWX) networks. The GEONOR TB-200 is the primary sensor selected for these networks. A secondary sensor (Pluvio) with a large storage capacity has been selected for use in remote locations with high precipitation regime. In 2002/03, Environment Canada has begun installing these sensors at RCS/SWX stations which were scheduled for modernization. Analysis of the results of the observations from these sensors (Geonor only so far) are now being analysed on a regular basis. The results gathered so far are presented here.

The results document the sensitivity of the Geonor as evidenced at several stations. The analysis also will show the sensitivity of the Geonor to external phenomena such as wind pumping, diurnal effect, temperature and/or solar heating dependencies, etc.). New and old algorithms to process the signal from the sensor and to derive precipitation have been analysed and compared. As a result of this analysis, we are proposing that a new concept of reporting and a new algorithm for processing the precipitation. The presentation will also include some results from a preliminary study of the snow sensor which reports snowdepth and on the associated processes to derive snowfall from this sensor.

Future development will include a multi-parameter precipitation algorithm.

PB.40

A New Winter Precipitation Gauge for Collecting Frozen and Liquid Precipitation

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Although snowfall and other forms of winter precipitation affect a wide range of human activities, measuring winter precipitation accurately presents a challenge. The official Canadian instrument for manual measurements of winter precipitation is the MSC Nipher shielded snow gauge. Weighing precipitation gauges are frequently used for automated weather stations because they are suitable for frozen winter precipitation and their output can be recorded by dataloggers. They tend to underestimate snowfall, particularly during windy conditions even when windshields are used. They also may experience a buildup of ice and snow on the interior walls of the collector. A prototype of a simple innovative design for a precipitation gauge suited for measuring the water equivalent of frozen precipitation during sub-zero winter conditions is described and evaluated using data from three locations. The device combines the ability of automotive antifreeze to melt snow, a revolving ball wetted with antifreeze to improve the catch efficiency of the snow, and the concentrating effect of the revolving ball being placed half submerged in the catchment area. Precision pumps are used in combination with a liquid level sensor to maintain the liquid level in the catchment area and record the amount of liquid precipitation removed. A battery powered drive motor turns the ball at 1 RPM. A liquid reservoir and a precision pump provide a supply of antifreeze to compensate for evaporation and maintain the liquid level. The gauge is battery powered and generates output that can be recorded by a datalogger. The gauge proved reliable for a wide range of weather and precipitation events during two years of testing at the Ottawa CDA climatological station. Without any wind shielding, the gauge consistently equaled or exceeded the catch of automated weighing gauges such as the Fischer and Porter, or the Belfort. Preliminary results of tests at sites in Missoula and West Yellowstone, Montana are also presented to illustrate the potential usefulness of the gauge for a range of climatic conditions.

PB.41

The Study of Case of the South Atlantic Convergence Zone (SACZ) for the Transport of Radioactive Material, Using the Numerical Modeling

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This work has the objective to carry through a study of the case in the region Angra dos Reis (Brazil), on the event occurred in day 8 of December 2002, that resulted in flooding and landslides in the region. The interest of this research, if makes in the measure where it comes to occur a hypothetical emptying of the radionuclides deriving of the nuclear complex Angra dos Reis. Which will be the direction that these residues will be carried? In the day of intense rains the called predominant system of the South Atlantic Convergence Zone (SACZ), influenced in the trajectory of the radioactive material. To carry through this simulation, it will be used given of reanalysis of the National Centers Environmental Prediction - NCEP and models will be the Regional Atmospheric Modeling System -

RAMS and of trajectories developed in the University of São Paulo. The results gotten in this research can be used by the governmental agencies, for elaboration of mitigation control.

PB.42
A Detailed Analysis and Comparison of Selected ELBOW 2001 Intensive Observation Days
Lisa Alexander
Earth and Space Science Department, York University, Toronto, Ont.

Effects of Lake Breezes on Weather (ELBOW) 2001 was a field project done from June to August 2001 in Southwestern Ontario. Data was collected on Intensive Observation Days (IODs) or when forecasters could foresee lake breeze development for the day. The data collected included radiosondes, mobile surveys, mesonet, X-band doppler radar, wind profiler, and data taken from a Twin Otter aircraft. The data is now being used to better understand how lake breezes interact with one another and other boundaries, and how they may help to enhance storm activity in Southwestern Ontario. With this new information, we hope to improve forecasts in the region.

It has been realized, through a more in depth look at some of these IODs, that days with similar initial conditions (background flow, synoptic conditions, etc..) may not have the same outcomes, or development. These particular days are being studied in order to understand what may cause a lack of development, or severe storm development, and how lake breezes interact or help to modify these situations.

PB.43
From mm to cm…: A study of Snow/Liquid Ratios ov er Quebec – II
Ivan Dubé
MSC - Quebec region

Snowfall density (or the snow/liquid ratio) is a parameter which has been somewhat neglected by the meteorological community. The systematic use of the "10 to 1" rule to convert the QPF (in mm) into snow accumulations (in cm) is a good proof of that fact. However, snow density is important or even essential in many sectors or applications (e. g. snow removal, transportation, construction, avalanche & hydrological forecasting, etc). The need for specialized precipitation forecasts is increasing so we should recognize the necessity to develop efficient ways of forecasting snowfall density in the near future.

The main objectives of this study were to develop awareness of this problem among forecasters and also prepare them to face existing and upcoming challenges with respect to precipitation forecasting. To do so, a climatological study of snow/liquid ratios based on near 500 events over 8 observing sites has been performed. Then, all the theoretical information available on the subject was used to identify the various physical processes which determine snow density ice-crystal growth, accretion, aggregation, fragmentation and change of phase. These processes are strongly dependent on several meteorological parameters such as: temperature profile, relative humidity profile, vertical motion, low-level winds and ground temperature. They also depend on the crystal type or " habit " (eg dendrites, plates, columns, needles).

Results from this climatological study and several others were then analysed and compared with theory. A good agreement was found between theory and observations, which confirms their usefulness in the development of new forecast tools. Existing diagnosis/forecast techniques were evaluated and found incomplete and inadequate. Several new tools have been proposed, leading to the development of a snow/liquid ratio forecast algorithm. This algorithm includes all processes and parameters involved and considers their specific impact with respect to each crystal type. It gives us the capability of diagnosing/forecasting snowfalls among 5 categories (very heavy, heavy, average, light, and very light snow), to which are associated a mean snow/liquid ratio, or conversion factor (4, 7, 10, 15, 20). Verification of the algorithm on over 200 cases has shown encouraging results (87% accuracy).

Beyond snow accumulations, other aspects of weather forecasting related to snow density were studied (e. g. impacts on blowing snow and hydrological forecasts). Future developments include: more verification, completion of climatology and integration into numerical models.

Poster Session C

Session d'affiches C

Thursday 5 June

jeudi 5 juin

Penthouse Lobby

Niveau penthouse

PC.1

Sea Level and Current Variability over the Scotian and Southern Newfoundland Slope

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Sea level and surface current variability over the Scotian and southern Newfoundland Slope are studied using eight years of TOPEX/Poseidon satellite altimeter data, in conjunction with frontal analysis data and numerical model results. Anomalies of geostrophic surface current normal to satellite ground tracks from altimetric sea level anomalies calculated relative to local means. The altimetric current anomalies are combined with a model mean circulation field to construct nominal absolute currents. The altimetric results exhibit strong current variability over the Scotian and southern Newfoundland Slope, seemingly associated with the high occurrence of Gulf Stream rings and the proximity to the Gulf Stream. Comparisons with of altimetric currents with frontal analysis data, ADCP measurements and CTD observations indicate altimetry's capability of detecting the Gulf Stream rings. There are substantial seasonal variations in the cyclonic slope circulation, stronger in winter/fall and weaker in summer/spring. The winter circulation was strongest in 1998 and weakest in 1996, presumably related to an oscillation of the Gulf Stream position and a fluctuation of the Labrador Current transport.

PC.2

A Modelling Study of Physical Processes of Ocean Circulation over the Meso-American Barrier Reef System

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Department of Oceanography Dalhousie University, Halifax

We use a two-way nested-grid ocean circulation model to study the physical processes of circulation and temperature/salinity distributions over the Meso-American Barrier Reef System (MBRS) of the western Caribbean Sea. The nested-grid model has a fine-resolution (5 km) inner model embedded in a coarse-resolution (18 km) outer model. We follow Sheng et al. (2003) and use the semi-prognostic method to exchange information between the inner and outer models through the model momentum equations. To examine the role of wind stress, boundary forcing and local density gradients in the MBRS, we conduct four numerical experiments. In the first experiment (control run), we integrate the nested-grid model for two years and force the model with the monthly mean surface flux forcing and monthly mean volume transport across the outer model open boundaries. In the other three experiments, we drive the model with the external forcing and model parameters same as those in the control run except that (a) the wind stress is set to zero in the no wind stress case; (b) volume transport across the outer model open boundaries is set to zero in the no boundary forcing case; and (c) temperature and salinity at each model grid point are set to constant values in the uniform density case. We calculate the annual mean transport streamfunction, currents, temperature and salinity from the second year model results of each experiment. We demonstrate that the boundary forcing of the outer model and local density gradients play a very important role in driving the general circulation in the MBRS. The surface wind forcing plays an important role in driving the near-surface circulation, but plays a secondary role in driving the depth-integrated flow in the region.

PC.3

Optical Buoy Network in the St. Lawrence Estuary and Gulf

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The St. Lawrence estuary and Gulf region is a complex ecosystem characterized by a large spatio-temporal variability of its biological and physical properties resulting from the interactions between high freshwater runoff, strong tides, local winds and a complex bathymetry. Recent results from the St. Lawrence Optics Program showed that the optical properties of this ecosystem are a complex mix of type 1 and 2 water masses having a strong seasonal signal. As part of this research program, we devised a buoy network that will help characterize the higher frequency variability of this ecosystems

optical properties with the goal to allow more accurate interpretation of the ocean colour remote sensing data that is available.

Built around a low cost standard navigation buoy, the instrumentation consists of a CTD equipped with a fluorometer, two radiometers to measure irradiance and radiance at seven wavelengths, a PAR sensor, and sensors for measuring wind speed, wind direction, humidity, air temperature, and air pressure. The data is transmitted to the Maurice-Lamontagne Institute using a high-speed VHF modem or satellite link depending on buoy location. A graphical interface allows the visualization of the data and the buoy parameters (power, tilt, orientation) in real-time. When completed, the network will consist of four buoys moored at key locations and will become an integral part of the Coastal Thermograph Network. The presentation will include comparison between wavelength ratio and measured fluorescence during the 2002 season.

PC.4

Vertical Mixing in a Three-Dimensional Ice-Ocean Model of the Gulf of St. Lawrence

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The Gulf of St. Lawrence is a biologically productive semi-enclosed northern shelf sea with large river runoff, tides, eddies and internal waves, and a strong seasonal cycle characterized by a nearly complete sea ice cover during 3 to 4 months of the year. The circulation is estuarine with the deeper inflow of Atlantic waters in a smooth 300 m deep valley ending some 1500 km into the continental shelf, lying below a permanent cold intermediate layer produced by winter mixing and inflows from the Labrador Sea, Hudson Bay, and the Arctic Archipelago. The vertical turbulent mixing of momentum, freshwater and heat has an important control on the circulation at all scales, especially long period changes that integrate the effects of small scale turbulent events. Models of turbulent transfer in the water column must, either explicitly or implicitly, account for several physical processes and at the same time be of general applicability to estuarine and ocean processes. This study compares the performance of a hierarchy of vertical mixing turbulent closure schemes using a three-dimensional ice-ocean model of the Gulf of St. Lawrence that includes detailed forcing at a resolution of 5 km in the horizontal and 5 m in the vertical. Results of annual simulations using the different turbulent closure models and selective forcings are analyzed and compared with observations. The turbulence closure models based on a prognostic equation for the turbulent kinetic energy (k model) compare well with observations. The results show the importance of the vertical diffusion of turbulent kinetic energy to both mixed layer deepening and estuarine circulation intensity. Use of a prognostic equation for the dissipation rate (k- model) does not significantly improve the comparison with observations, although it does provide increased numerical stability. For the k- model, a flux boundary condition for the dissipation rate is investigated. Finally, the effect of the steady state Richardson number and parameterizations for counter gradient fluxes and internal wave breaking are examined.

PC.5

Nearshore Currents and Turbulent Exchange Processes during Summer Stratification in Lake Ontario

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The nearshore circulation and turbulent exchange processes during summer stratification in Lake Ontario have been examined using a time series data of horizontal velocity profiles from broadband ADCPs and temperature profiles at two thermistor moorings. Energy spectra of currents and temperature shows a primary peak located at 10-12 day period due to large scale circulation and a secondary peak at near-inertial frequency-band. The horizontal turbulent exchange parameters during summer stratification shows nonisotropic conditions in the surface layers and isotropic conditions in the bottom layers at the offshore location. The alongshore horizontal exchange coefficients (Kx, Ky)

are generally higher than cross-shore components. However, during upwelling episodes horizontal exchange coefficients are reduced in the surface layers and increased in the bottom layers. Full upwelling events are characterized with weak static stability and reduced vertical current shear in surface layers. Near bottom layers are affected by intense turbulence associated with increased vertical current shear. During downwelling events with migration and intersection of the thermocline with the bottom, the vertical exchange coefficients (Kz) are relatively small due to weak turbulence.

PC.6

Grain Textures and Morphology to Assess Climate Impacts on Mineral Weathering in Three Forested Ecosystems Soils of Quebec: Duchesnay, Laflamme and Tirasse Watersheds

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The forest is a renewable resource. It is important to develop its management so as to assure the perennity of this resource for the future generations. The study of weathering rates in the forest soils may furnish keys to understand how the soils can provide the nutrients necessary for the trees growth. We focused the weathering rates on weathering rates in soils derived on Precambrian granite basement in the Duchesnay experimental forest station watershed and two others, Laflamme and Tirasse watersheds in Quebec. Many field and laboratory studies examine the decomposition of quartz-bearing source rocks and the resultant detritus. Although the principles and mathematical treatment of size and shape analyses have been dealt in sedimentary petrology, they are an integral part of both mineral and structure analysis of soil materials. Particularly, dissolution governs the persistence of mineral components in soils environment.

The aim of this paper is to express qualitatively and quantitatively the frequency distribution of particular shape and size ranges as part of the description of the material within soil profiles and as a basis for interpretation of the silicate mineral dissolution and precipitation in the weathering processes. On a shorter geological or better pedological time scale (about sixty to one hundred years), weathering is visibly evident in the progressive etching of individual grains before it is seen in total assemblage composition. As observed below in Venezuela (Brantley et al. 1986a, b), weathered grains may have etch on their surfaces and show a gradual change from triangular pitted surfaces to rounded surfaces. Apart from etching, the shape of mineral grains as seen under the scanning electronic microscope (SEM) in particular can provide useful information about their weathering history. Indeed, a correlation between grain sizes, textures, and surfaces may furnish a good indication on weathering rates and paleoclimates histories in soils profiles. In this way we will be able to assess the weathering rates and how the nutrients are delivered in the forests ecosystems.

The SEM observations of quartz grain surfaces suggest too that various salt solutions promote the development of pits and precipitation and solution textures. Investigations of etch pit densities on naturally weathered surfaces suggest that dissolution from etch pits becomes increasingly important with long exposure times to weathering conditions (Anbeek et al. 1994). This study will govern the partners to make the sustainable forest management by understanding of the forest soils environment and evolution.

PC.7

Modeling Drought and Drought Risk in Alberta

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Drought reoccurrence is part of the prairie landscape. The vulnerability of agriculture to impending drought can be reduced by providing better lead time. Towards these goals we have used a soil moisture budgeting and drought prediction model that operates in real-time. The model produces results across Alberta at the township scale. The water budget is based on a daily time-step, that links to a Palmer Drought Index calculated monthly. The model requires meteorological, soil and crop

parameters at a township scale. The model predicts soil moisture for a crop of wheat, and currently we are working on a model for native pasture. We can predict the location and severity of the drought, and another component of the model is to compare current conditions with past drought so we can predict how much precipitation is needed to end or ameliorate a drought, and the probability of obtaining that precipitation. Alberta Agriculture are using this model operationally for crop insurance plans and drought insurance. Such a system should help the agricultural administration to understand the drought process.

PC.8

Energy Partitioning in Post Fire Canadian Boreal Forests

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Fire is well recognized as one of the main forest stand renewal agents. As members of Fluxnet, a global network of micrometeorological tower sites, we are studying the influence of climate and disturbance on carbon cycling and energy balance in post-fire sites. About 2 million ha of forests burn annually in Canada, and more than 7 million ha burn during extreme fire years. We are continuously measuring the exchanges of carbon dioxide (CO_2), water vapour and radiation, among several other variables, in two-post forest fire sites differing in their time since fire. The sites are at BERMS in the boreal forest of Saskatchewan near Waskesiu Lake (WL, 54° 15'N 105° 53'W), burned in 1998, and Montreal Lake (ML, 54° 15'N, 105° 53'W), burned in 1989. In this paper we analyze the patterns and characteristics of energy partitioning into sensible (H), latent (LE), and soil (G), heat fluxes in both sites. The WL site is characterized by numerous trembling aspen suckers to a height of about 1 m, with smaller regenerating jack pine and black spruce seedlings. Dead tree boles are still standing but there is also much deadfall and soil exposed. The ML site is vegetated by jack pine trees, about 3 m height, with some trembling aspen, balsam poplar and black spruce. H and LE fluxes were calculated following the eddy covariance technique, based on measurements using CSAT3 3-D sonic anemometers (Campbell Scientific Inc., Logan, Utah), located at the same elevations where vapour density measurements were made. In WL, measurements were made at a 7.7 m height from April 2001 to August 2002, when sensors were raised to a 20 m height. Water vapour densities were measured with closed-path (LI 6262, LICOR Inc. Lincoln, NE) and open path (LI 7500 LICOR Inc., Lincoln, Nebraska) IRGA analyzers at each height, respectively. In the ML site, water vapour densities were measured with an open path IRGA analyzer (LI 7500 LICOR Inc., Lincoln, Nebraska), at a 5.2 m height from April 2001 to September 2002, when sensors were raised to 9.1 m. All H and LE Fluxes were calculated after coordinate rotation and corrected for water vapour density. G fluxes were measured with soil heat flux plates and calculated including the storage term. The daily mean combined H + LE + G values are similar in both sites throughout the year, averaging about 16 MJ day^{-1} by mid-summer, and approaching zero by the end of October, or when a snow pack remains on the ground. Summertime daily mean LE is more than twice in the older forest site ML, or about 5 mm day^{-1}, as compared to 2 mm day-1 at the WL site. Accordingly, both H and G are larger at the WL site than the ML site. On average, during the months of June, July and August, the H/LE ratios are about 0.4 and 1.25 in ML and WL, respectively. Therefore, when soil water content is not a limiting factor, most of the available energy will be driven to transpiration in a post-fire juvenile boreal forest. Partitioning of energy is controlled by the successional development of post-fire vegetation. Extensive fires will cause a greater portion of energy to be dissipated as sensible heat with the potential to affect regional, and perhaps, global climate.

PC.9

Resistances in the Pathway for NO2 Uptake by Soybeans

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The ability of vegetation to take up NO2 from the atmosphere has been well established. Studies have shown that the NO2 uptake by a vegetated surface is significantly larger than NO emissions from the plant/soil system, so such surfaces are an important net sink for NOx. Therefore, models of

photochemical smog, and subsequent management practices, need to consider paramaterizations of the NO_2 flux. An important question to be answered is whether the pathway for NO_2 uptake is similar to that for water vapour loss, or whether there is an additional internal resistance for NO_2. Researchers working on a variety of tree and crop species have come to different conclusions about this question.

Soybeans were chosen for this investigation because they represent a large potential NO_2 sink in the smog-impacted region of southern Ontario, and the NO_2 pathway resistances have not previously been investigated. Controlled environment studies on soybean leaves will be presented, and it will be shown that NO_2 uptake was well predicted from a knowledge of the transpiration losses. This implies that there is no significant internal resistance for NO_2 in soybean leaves, and the substomatal concentration of NO_2 is not statistically different from zero.

PC.10

Nitrous Oxide Production in and Emission from Cultivated Soil Under Two Contrasting Management Schemes

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Concern regarding the environmental implications of increasing atmospheric nitrous oxide (N_2O) concentrations has stimulated research into identifying its sources and sinks and into compiling global N_2O budgets. Cultivated soils have been implicated as major contributors to total N_2O emissions, however, given the extreme spatial and temporal variability of N_2O production in soils and the scarcity of continuous, long-term N_2O flux measurement programs, resolving the 'strength' of soils as an N_2O source has been difficult. To date, global N_2O budgets have largely omitted contributions from winter and spring emissions. In cold, temperate climates of Canada and northern Europe, significant N_2O losses have been observed over winter and during the spring thaw period. A field study was conducted at the Elora Research Station (43° 39' N, 80° 25' W) from January to December 2002 to identify relationships between climate, soil physical (T, qv, WFPS) , chemical (NH_4+, NO_3-, DOC, DON) and biological (microbial biomass C and N) properties, soil N_2O concentrations and the surface N_2O flux. Two contrasting management schemes (conventional vs. 'best' management) were studied and the potential for N_2O release from soil, particularly during the spring thaw period, was quantified. The soil atmosphere was sampled by use of permanently-installed soil gas sampling probes, and soil N_2O concentrations were determined by gas chromatography. A tunable diode laser trace gas analyzer (TDLTGA) system was used to continuously measure atmospheric N_2O concentrations and surface N_2O fluxes were determined using the flux-gradient approach. Results of this study, which are to be presented, will help elucidate the role of soil management (tillage and fertilization) on the physical, chemical and biological condition of soil, which ultimately govern N_2O production and emission. A general model predicting the N2O flux from soil, based on soil N_2O concentration, water-solubility of N_2O, and soil temperature and air-filled porosity, could be used to estimate the contribution of cultivated soils that undergo freezing and thawing to total N_2O emissions, thereby refining the global N_2O budget.

PC.11

Measurements of Nitrous Oxide and Methane Emissions from a Municipal Solid Waste (MSW) Landfill in Southern Ontario

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As part of an ongoing University of Guelph research project assessing alternative landfill covers, measurements of methane (CH_4) and nitrous oxide (N_2O) emissions were made at the decommissioned Park Road landfill in Grimsby, Ontario. Measurements were made between June 26 - July 9, 2002, and July 31 - August 27, 2002 to gain a better understanding of the dynamics of greenhouse gas emissions from a landfill and to monitor the extent to which four different meteorological conditions influenced temporal variations in landfill gas emissions. Measurements of barometric pressure, wind speed, air temperature and precipitation were all monitored on-site. During

the two measurement periods, sampling was divided between an area that was a suspected biogas 'hot spot' with total grass kill and an area with a dense grass cover. Gas flux measurements were obtained with a micrometeorological mass balance measurement technique (Integrated Horizontal Flux (IHF)) in conjunction with two Tunable Diode Laser Trace Gas Analyzer (TDLTGA) systems. Fluxes of N_2O were found to be negligible over the duration of the experiment. In contrast, emissions of CH_4 were found to be large and varied both spatially and temporally. Variations in flux values between the biogas 'hot spot' area and the densely grass covered areas of the landfill were evident and were likely caused by dynamic processes within the landfill itself. Temporal variations in CH_4 fluxes were also evident and could be explained partly by a combination of the meteorological conditions monitored. Air temperature was found to have no significant influence on CH_4 fluxes, while precipitation caused a rapid decline in emissions during rain events, followed shortly after by a spike in emission rates. Correlations between CH_4 fluxes and wind speed, as well as CH_4 fluxes and barometric pressure were weak, though were found to be statistically significant. It is believed that the wind speed itself does not influence CH_4 fluxes but rather it is the turbulence and the resulting dynamic pressure forces generated that are responsible for the observed correlation. Of the meteorological conditions monitored, barometric pressure was found to have a significant negative correlation with CH_4 fluxes and could explain the most variation in the data for both diurnal and weekly time scales.

PC.12

An Experimental Method to Investigate the Relationships between Lagrangian and Eulerain Length Scales above an Agricultural Surface and in a Forest

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In this study, two experiments were carried out to investigate the relationships between Lagrangian and Eulerian length scales, the first above a flat agricultural field with a low stubble/clover cover at the Elora Research Station and the second in a uniform deciduous forest (h=13 m tall) at the Camp Borden. Using the measured mean CO_2/H_2O concentration profiles, the vertical velocity variance profile, and the CO_2/H_2O fluxes above the agricultural field, the vertical Lagrangian length scale (L_{Lw}) was estimated based on the Lagrangian dispersion theory for CO_2 and water vapor. The vertical Eulerian length scale (L_{Ew}) above the agricultural field and in the forest was calculated using the integrated autocorrelation. The vertical Lagrangian length scale estimated from latent heat flux measured above the agricultural surface generally agrees with the empirical mixing length expression ($l_m=kz$, where k=0.4 is van Karman's constant, z is height) in near neutral and stable conditions. The vertical Lagrangian length scale increases in unstable situations above the agricultural surface. The measured vertical Eulerian length scale is almost twice the corresponding Lagrangian length scale above the agricultural surface, which means that the common used assumption of $L_{Ew}=L_{Lw}$ seems not tenable in this case, even in near neutral conditions. Preliminary results from the forest suggest that the measured vertical Eulerian length scale in forest is in qualitative agreement with the empirical mixing length expression, but with greater scatter close to the ground. It was found that the calculated dimensionless Eulerian length scale in forest $(L^*_{Ew} = (u_* /w).L_{Ew}/h)$ agreed well with other studies.

PC.13

Comparing Eddy Covariance and Gradient Flux Measurements over an Agricultural Field

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This paper compares measurements of carbon dioxide and water vapour fluxes obtained using two independent open-path eddy covariance systems against fluxes obtained using the flux-gradient method. The study site was a clover/stubble agricultural field located at the Elora Research Station near Guelph, Ontario. The two open-path eddy covariance systems were installed at the site to obtain year-round flux measurements while 4-point profiles of carbon dioxide, water vapour and wind velocity were measured with a closed-path sensor during a one month period in late summer, 2002. Eddy covariance fluxes were corrected for spectral loss due to sensor height but no energy balance

correction was applied. Flux gradient measurements were computed using standard Monin-Obukhov stability corrections developed from the 1968 Kansas measurements. Gradient fluxes were computed for each of the three layers as well as averaged by linearizing the gradients assuming logarithmic, stability corrected surface-layer profiles.

Preliminary results indicate that the two flux measurement techniques agree quite well for water vapour and somewhat less so for carbon dioxide. This paper will present results of these flux measurements and discuss corrections used. The results suggest that the flux gradient technique is an effective method for determining trace gas exchange from a horizontally homogeneous, extensive surface. Although this technique requires precise measurements of scalar gradients, it does have the advantage of not requiring fast response sensors. A single sensor combined with an appropriate sampling system has the added advantage of allowing measurements over multiple treatment plots with comparable accuracy to eddy covariance measurements. As interest in surface-atmosphere trace gas exchange continues to grow, the flux-gradient technique becomes an attractive alternative for experimental studies.

PC.14
Variability of the MacKenzie River Basin Winter Anticyclone
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Variations in the anticyclonic activity over the McKenzie River Basin are studied based on the 14-year ECMWF Re-Analysis dataset that covers the 1979-1993 period and a tracking model that tracks anticyclones through their lifetimes and monitors their growth. Distributions of anticyclones' frequencies of genesis and lysis and also of their properties of development such as their lifetimes, intensities and growth rates are generated for the broader North American region.

Spectral decomposition into a number of wavelength bands is used to assess the contribution of different wavelengths to anticyclonic activity over the McKenzie River basin. The results show that some wavelengths contribute to anticyclonic development in the MRB more than others. The properties of development in the corresponding scales are evaluated and their interannual variations are discussed in relation to the El-Nino oscillation and to some prominent teleconnection patterns.

PC.15
Evaluation of Passive Microwave Derived Snow Cover Parameters for the MacKenzie Basin, 1987 - 2002
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The Climate Research Branch of the Meteorological Service of Canada (MSC) has a longstanding research program in the development of land cover specific algorithms for estimating snow water equivalent (SWE) from passive microwave brightness temperatures. A suite of land cover sensitive algorithms have been developed at MSC that are capable of retrieving SWE information with operational accuracy for the open prairie and boreal forest environments of western Canada. Research towards applying these algorithms to the Mackenzie Basin has been ongoing since the inception of the Mackenzie GEWEX Study (MAGS). While the Mackenzie Basin presents some real challenges to the application of passive microwave radiometry due to mountainous terrain in the west, useful SWE information can be retrieved for the lowland areas of the basin. To date, this data has been utilized for initialization and evaluation of various MAGS related modeling efforts.

In this study, SWE and snow extent derived from Special Sensor Microwave/Imager (SSM/I) brightness temperatures were derived for the snow cover seasons of 1987/88 through 2001/02. SSM/I derived snow extent data were compared with in situ measurements and weekly snow extent charts from NOAA NESDIS to assess the degree to which the MSC algorithm suite accurately determines the temporal and spatial patterns of autumn snow advance and spring snow retreat. The datasets agree

well at a weekly resolution, with areas of disagreement resulting from passive microwave underestimation of snow extent. This bias is caused by problems detecting a thin snow pack in the autumn, and a wet snowpack in the spring. The SSM/I SWE data is more difficult to evaluate directly because of a lack of suitable, spatially distributed SWE evaluation datasets for the basin. Because of this, an indirect assessment was performed by examining the variability in passive microwave SWE retrievals. Confidence in passive microwave SWE estimates is low for pixels that contain a narrow range of SWE values, and exhibit little intra- and interseasonal variability. Heavily vegetated subregions of the basin are characterized by SWE retrievals of this nature, indicating a domination of the microwave emission signal by vegetation, rather than the variable scattering influence of snow cover. Synthesis of the snow extent and SWE evaluation results will lead to the development of basin wide confidence maps for passive microwave retrievals of snow cover parameters.

PC.16

The Mackenzie GEWEX Study (MAGS) Data Archive

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The MAGS Data Archive consists of climatological, operational and special enhanced observations. Most of these data can be accessed online through the MAGS web site. The online component provides several gigabytes of data collected in the study area, as well as metadata describing the data and the objectives, background, status, and clients for the project. Selected data sets are also available in near real time. These include GOES and AVHRR satellite imagery and enhanced observations from the MAGS surface sites and buoys. The enhanced data sets from surface sites contain enhanced temporal resolution data (for example, 15 minute pressure measurements) and non-standard measurements (such as soil temperatures).

These data have also been collated into thematic datasets such as specific case studies, water year studies, and water and energy budget studies. These archives will provide a lasting resource for future climate studies.

This presentation will describe the contents, structure and utility of the MAGS Data Archive along with examples of its application in climate research.

PC.17

Fusion of Oceanographic Data for Nowcasts

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[3]*Oceanografix*

A significant amount of real-time oceanographic data is available for oceanographers to use for determining the current state of the ocean. This data is from fixed and drifting buoys, vertical profiling buoys, satellites, and expendable bathythermographs from ships and aircraft. The Ocean Work Station (OWS) in the Meteorological and Oceanographic Centre at the Canadian Naval Operations Support Centre (Pacific) has been developed to ingest this data from the Global Telecommunications System, Canadian Marine Environmental Data System (MEDS), NOAA AVHRR, World Meteorological Organization formatted messages as well as allowing for manual input.

The OWS is designed to be used by sailors with limited oceanographic training and incorporates the ability to grid the data at discrete depths or at depths containing significant oceanographic features. Routine OWS products are charts of sea surface temperature, temperature at 150 metres, mixed layer depth, sound channel axis depths, and ocean features plots. The OWS is also capable of producing three-dimensional gridded temperature and sound velocity fields for further analysis. Recent

developments include the input and quality control of NOAA AVHRR data from the NOAA Satellite Active Archive and future developments will include the use of Modular Ocean Data Assimilation (MODAS) data from the United States Navy to replace LEVITUS 94 data for background fields. This data may be used for the initial conditions in a regional oceanographic model being developed at the Institute of Ocean Sciences. This presentation will describe the capabilities of the OWS.

PC.18

Predictability and Short-Medium Range Forecast Tools using Ensemble

Serge Desjardins [1], Hal Ritchie [2], Garry Pearson [1], Andrew Phillips [1] and Bjarne Hansen [2]
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Interest is rapidly growing in the marine user community for prediction products extending out beyond 5 days. Users generally have to plan well in advance when working on fishing grounds that require 2 days travel in each direction. Significant safety concerns are at issue. Current marine forecasts are largely deterministic and extend out to 3 days only. Mariners often indicate that they would like an indication of the confidence in the forecast product toward the end of the period. Ensemble prediction systems hold promise in fulfilling this need. Ensemble forecast systems currently depict forecast scenario probabilities rather than deterministic solutions. The degree of convergence of the ensemble members could be interpreted as an indication of the inherent predictability of the atmosphere for a particular situation. The Atlantic Environmental Prediction Research Initiative (AEPRI) has recently made use of the CMC ensemble system in providing different output products on internal websites which focused on the Atlantic Region. Wind category probability as well as various displays of the surface synoptic fields from the ensemble's members are available to the forecasters in the Atlantic region since January. The graphical output expresses, quickly and clearly, the likelihood of wind strengths exceeding selected critical thresholds during the next ten days. The wind category probability maps give forecasters a new tool to assess the likelihood of significant winds affecting marine areas during the next ten days. By using this tool, forecasters will be able to provide marine interests with better decision-making guidance.

Mentioned website:
http://aepri1.dart.ns.ec.gc.ca/aepri_ensemble_synop
http://aepri1.dart.ns.ec.gc.ca/aepri_ensemble_wind

PC.19

Webtide and Webdrogue: Open Source Tidal Predictions and Trajectory Modelling

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Numerical models are complex beasts that generally require specialists to run them and process the output for use by colleagues, clients, and the general public ('the users'). Our poster will describe software that allows the user to interact directly with model output for two applications. WebTide is a desktop application that allows the user to extract tidal predictions for any place and time inside the available model domains. The primary model domain is the Northwest Atlantic Ocean from Cape Cod to Davis Strait. WebDrogue allows the user to track particles in flow fields created by combining the seasonal mean currents, the tidal currents and additional contributions due to wind forcing. The particles can be tracked at the surface and at 25 and 100 m depth for several regions of Atlantic Canada. The two applications use a very similar interface and allow the user to be completely independent of the modellers. The interface is based on Java so that it can be supported on both Windows and Linux/unix platforms and uses open source tools for the mapping and plotting functions. All the source code is provided with the distribution. The software is designed so that new model domains and data files can be added easily and the interface is weakly coupled with the underlying application so that the interface can be easily modified for other applications.

WebTide and WebDrogue can be downloaded from http://www.mar.dfo-mpo.gc.ca/science/ocean/coastal_hydrodynamics/main.html

PC.20

Impact of Assimilating a New Observed MSSH in an Operational Ocean Model

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Herein we describe the implementation and impact of assimilating an observed Mean Sea Surface Height (MSSH) on an operational ocean model for the North Atlantic. The model assimilates Sea Level Anomalies and a prescribed MSSH. The observed MSSH is derived from a combination of drifter observations, in-situ density profiles and climatology. A twin numerical model run experiment is carried out where only the assimilated MSSH differs. The first run assimilates the new observed MSSH while the control run assimilates a 3 year model derived MSSH. Both model runs start from a prescribed ocean state issued from the MERCATOR PSY-1 operational ocean forecast system for Aug 31 2001. Models are then integrated over 8 months assimilating SLA and MSSH. The new MSSH provides a stronger, sharper and more realistic, Gulf Stream, Labrador Current despite limited ¼ deg model resolution. Statistical comparisons with 14000 XBT observations are improved with use of the new MSSH. Drifter studies also show reduced rms model-observation differences.

PC.21

Cloud-scale Radar Data Assimilation Cycles

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Over the past decade, the cloud-scale radar data assimilation algorithm has been developed at the McGill University. A variational method, in which the dynamic core of the MC2 model coupled with the microphysics parameterization of Kessler (1969) is used as a weak constraint, is used to retrieved the different fields of the model prognostic variables from the S-band Doppler radar of McGill and its associated bistatic network. This makes the retrieval fields compatible with the initialization of the MC2 model. At the same time, the echo-free regions are filled by a linear wind analysis from single-Doppler data (Caya et al., 2002), which provides a realistic mesoscale flow. Furthermore, the assimilation of the near-ground refractivity index derived from ground targets leads a improvement in the humidity analysis in the boundary layer.

In the variational method, the convergence efficiency and the ability of a minimization algorithm to find the global minimum depend on the starting point of the minimization, especially in the presence of multiple minima. A continuous cycling assimilation procedure, in which the analysis from the previous cycle is used as the background field for the next cycle, is introduced to improve the analysis. From our preliminary research, which is performed by a single cycle including two assimilations with radar data of four successive volume scan of a shallow hailstorm on 26 May 1997, more realistic dynamic features are observed in the retrieval fields. Furthermore, the retrieval fields from the cycling assimilation are used to initialize the MC2 model to evaluate the enhancement on the forecast.

PC.22

Scale-Dependence of Predictability in Precipitation Nowcasting

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Information on the predictability of precipitation features by scale can be used to improve the precision of nowcasts. Noting the often localized, intermittent nature of rainfall, the wavelet transform

is used to develop measures of predictability at each scale. This information is used to develop an optimal filter to progressively remove less predictable scales with increasing forecast lead time. Alternatively, results on the scale-dependence of predictability can be used to produce probabilistic rainfall forecasts.

These methods are applied as part of MAPLE (McGill Algorithm for Precipitation nowcasting by Lagrangian Extrapolation). At present, MAPLE incorporates variational echo tracking, a semi-Lagrangian advection scheme, optimal scale filtering for conventional forecasts and rainfall probability forecasts produced according to the evolution of predictability with scale for each forecast lead time.

The method has been applied to radar composites of rainfall reflectivity over much of the continental U. S. A., and has also been implemented for operational forecasting and to provide input to automated forecast generation tools at CMC.

PC.23

High-Resolution 4-D Water Vapour Estimation using the Global Positioning System

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Since 1993, twenty-four or more Global Positioning System (GPS) satellites have provided all-weather worldwide coverage and positioning capabilities. The GPS signals experience delays in the neutral atmosphere, with the resulting range errors being dependent on the atmospheric water vapour. In recent years, novel techniques have been developed to derive slant wet delay estimates for all satellites in view. For a given GPS reference station, as many as ten or more satellites may be observed simultaneously, such that slant wet delay observations from a number of regional network sites may be used to model both the vertical and horizontal structure of water vapour using a 4-D tomographic modeling approach. It is possible to determine the spatial and temporal distribution of water vapour with high resolution in near real-time.

GPS is able to provide higher time resolution of water vapour observations at lower cost, with better all-weather capability, compared to the conventional ground-based techniques - such as radiosondes and water vapour radiometers. Great potential exists for using GPS technology to derive continuous near real-time estimates of water vapour in regional GPS networks for meteorological applications, such as assimilation into numerical weather predictions and studies of atmospheric processes. Potential also exists to use long-term GPS data sets for hydrology and climatology applications. With the growing availability of GPS reference networks worldwide, opportunities exist to exploit GPS as an atmospheric remote sensing tool for both global and regional studies.

In this paper, we present novel strategies for 4-D near real-time modeling of wet refractivity profiles and water vapour within a regional GPS network. Analyses consist of simulations to investigate optimal processing parameters and network configurations, and preliminary processing of data from existing regional GPS networks. The spatial and temporal resolution of water vapour estimates is analyzed – with reference to severe weather monitoring and climatology applications. Results indicate that wet refractivity profiles may be recovered with accuracies on the order of those achieved using conventional instruments and techniques.

PC.24

The Canadian Contribution to the Global Precipitation Mission

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The Global Precipitation Mission (GPM) is a proposed follow-on mission to the Tropical Rainfall Measurement Mission (TRMM). The launch date is 2008. Like TRMM, the GPM is a joint NASA-

NASDA mission but will include high frequency radiometers and second active radars (35GHZ). Using a constellation of satellites, GPM will provide coverage up to 83° latitude compared to the 40° limit of TRMM. This will provide unprecedented high resolution and near-global coverage of precipitation with 3 hour update. The GPM radars have a sensitivity of around 17 dBZ or about 0.4 mm/h of water equivalent. ESA is participating in GPM through a proposed contribution of a satellite with microwave radiometers. A potential option is a 35GHz radar.

Preliminary requirements analysis for mid and high latitude precipitation measurements was conducted and indicate the need for much greater sensitivity. The results indicate that light precipitation (below ~0.4 mm/h water equivalent) contributes substantially to the total precipitation in Canada and that this contribution roughly increases with latitude. This pattern is expected to apply to other mid/high latitude countries. As a result, the Canadian Space Agency is considering a proposal to jointly fund the development of high sensitivity 35GHZ radar to fly on the ESA satellite. The proposal is to increase the sensitivity to around 0 dBZ using available technology from Canada. Canada has world class expertise in snowfall measurements, snow on the ground measurements, airborne microphysical measurements, ground based weather radar, algorithm development, validation site, data assimilation, weather and climate modeling, hydrological modeling and radar technology that can make a substantial contribution to GPM. An inclusive and comprehensive Canadian science plan is being developed. The presentation will present an overview and status of the GPM project, a summary of the measurement requirements, the development of the science plan and the potential of Canadian participation in GPM.

PC.25

The Use of Satellite SAR Images to Assess Wind Potential of Coastal Regions

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The use of satellite-derived wind speed to assess wind energy potential of coastal regions and/or to select the optimal sites for wind energy potential measurements was investigated by Hélimax Énergie in collaboration with the Canada Centre for Remote Sensing. Wind speeds were estimated from the ocean radar cross section measured from RADARSAT-1 SAR (Synthetic Aperture Radar) images of coastal regions, and were compared to coastal mast observations providing estimates of their correlation and accuracy. The spatial variation of the derived winds and their sensitivity to SAR wind retrieval model parameters were also assessed.

This study is based on 39 RADARSAT-1 SAR images from the Gaspésie coastal region. SAR derived wind speeds at 1, 2, and 3 km from the coastline over opean water, and area-averaged wind speeds over 10 km x 10 km regions, were compared to mast observations and WAsP model results. According to these results, the advantages and disadvantages of using satellite images in estimation of wind energy potential of coastal regions will be presented.

PC.26

Ocean Wave Spectrum Measured by a Fully-Polarimetric SAR

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Ocean waves are a very important part of physical oceanography and can be completely characterized statistically by the two-dimensional directional wave spectrum. Over the past two decades, the potential for ocean wave spectrum measurements by Synthetic Aperture Radar (SAR) has been convincingly demonstrated. However, the problem of extracting wave spectra using SAR is indeed formidable. This is because of the fact that to construct SAR images, it is necessary to use information about the motions of both the smaller waves (capillary) and larger-scale waves on the ocean surface,

relative to the motion of a moving platform, whether airborne or satellite, where the radar is positioned.

The essential theory of SAR imaging of the moving ocean wave surface has been rather well understood. One of the major SAR imaging mechanisms is the so-called velocity bunching. The SAR imaging process is very complex and often nonlinear. Specifically, azimuthally traveling ocean waves are seldom well-imaged by SAR or RAR operating with conventional HH or VV polarizations. A new microwave technique to improve the measurement of directional ocean wave spectra was presented by Schuler and Lee in 1995. A new modulation process was identified and associated numerical simulations showed that azimuthally traveling ocean waves were now well-imaged, using this formulation. Up to now, however, ocean wave spectra were not extracted from the fully-polarimetric SAR data.

This paper follows the approach of Hasselmann and Hasselmann (1991) and Krogstad (1992), who derived a nonlinear integral transform relating the conventional SAR image spectrum to the ocean wave spectrum. In our formulation, a closed nonlinear integral transformation relation was derived describing the mapping of a two-dimensional ocean wave spectrum into a fully-polarimetric SAR image spectrum. Numerical simulation shows that the fully-polarimetric SAR can measure ocean waves which can not be imaged by conventional SAR. Moreover, a method for the retrieval of ocean wave spectra from airborne fully-polarimetric SAR image data is also described.

PC.27

Techniques for Surface Current Measurement on the Grand Banks Using High Frequency Surface Wave Radar

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Exploration and development of the oil and gas industry in the harsh environment on the Grand Banks of Newfoundland has brought with it the challenging problem of monitoring and reacting to environmental contingencies. In this context, the remote sensing of the ocean surface over substantial regions in the vicinity of maritime resource activities and the shipping lanes associated with them is becoming increasingly important to this industry as well as to renewable resource sectors such as the off-shore fishery. In particular, ocean surface current maps form a significant component of the overall description of maritime conditions.

Over the last decade, long range surface wave radar (SWR) operating in the lower end of the high frequency (HF) band (3-7 MHz) has been employed in the measurement of ocean currents on the Canadian east coast [1]. Initially, techniques to measure only the component of the current lying along the radar beam - i. e. the radial component - were employed. The basic theory involving the shift of the Bragg peaks in the Doppler spectra of HF ocean backscatter is well understood and has been validated many times as, for example, in [1].

The determination of the complete vector current from single-site HFSWR installations remains an ongoing challenge. Two such techniques form the basis of this presentation. The first of these gives a practical approach useful when currents do not vary greatly in magnitude or direction over significant regions or when general flow patterns rather than high resolution measurements are required. The second, using the equation of continuity, is a modification of that presented by Frisch and Leise [2] and involves less averaging while taking better account of intrinsic errors. However, it requires a knowledge of vector currents along one radar look direction. This is not a problem here as a part of the Grand Banks includes an area where dual coverage from radars located at Cape Race and Cape Bonavista exists.

For each technique mentioned above, radial radar current data are obtained using a simple FFT approach. This alone introduces an error of about 4 cm/s in the radial measurements. In spite of this, both the radial and tangential components of the current vectors are seen to correlate well with data

from satellite-tracked drifters. For the second technique, in which currents from the large area of overlap of two HFSWR's are available, two-site vector results are also used as a validation of the single-site extrapolations. The results are very encouraging with correlation between radar-deduced currents and drifter values being as high as about 0.9.

With ranges exceeding 300 km available for the present radar systems, surface currents may be obtained over more than 100,000 km^2 of the ocean surface. Enhancements in the results presented here for vector currents may be made by increasing the radar dwell times and implementing high-resolution spectral estimation techniques such as used in [3] for radial currents. Thus, it is clear that HFSWR is being established as powerful tool in the remote sensing of the ocean surface and is capable of providing valuable input to flow models necessary for purposes such as search and rescue operations, iceberg tracking, and the monitoring of contaminant discharge in the upper layer of the ocean.

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PC.28

The Inversion of HF Bistatic Doppler Radar Spectra for Arbitrary Water Depth - A Simulation

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It is well known that ocean surface parameters can be determined using high frequency (HF) surface wave radar (SWR). The received Doppler radar data is characterized as two significant "first-order" peaks surrounded by a higher order continuum. The second-order portion of this continuum, which can be described by a double integral, has been inverted to derive the ocean wave spectrum first by Lipa and Barrick [1] using least-squares estimation techniques without considering the shallow water effects. Howell and Walsh [2], and Gill and Walsh [3] then treated the inverse problem by singular value decomposition (SVD) for arbitrary water depth after reducing the double integral equation to a matrix equation. All of these studies involved monostatic radar cross sections and thus require dual-site operation to provide unambiguous directional information.

Recently, Gill and Walsh [4] presented the bistatic first- and second-order radar cross sections. The first-order (or Bragg) peaks are shown to be located at w = ± square root ($2gk_o\cos j_o$) if deep water is assumed. Here g is the acceleration due to gravity, k_o is the radiation wavenumber, and j_o is the bistatic angle defined as the half of the angle between radar transmitter and receiver as viewed from the scattering point. The second-order bistatic cross section contains three parts. Among them, the patch scattering, in which two scatters occur at the ocean surface far from the transmitter and the receiver, is dominant and will be treated in the inverse problem.

Here, an algorithm is developed to invert the bistatic second-order cross section. Simulated radar data are used and the water depth is set to be arbitrary. As for monostatic inversions, the bistatic cross section integrals are discretized. By representing the ocean wave spectrum as a truncated Fourier series, an overdetermined system of such equations results. The SVD method is invoked to solve the system. The non-directional ocean wave spectrum is obtained from the Fourier coefficient a_o.

This represents completely new, yet preliminary, work for bistatic HFSWR. When the long range radars located at Cape Race and Cape Bonavista, Newfoundland are operated in bistatic mode, as is the intention in the near future, the techniques presented here will be directly applicable to real radar data. With bistatic data available, directional wave parameters can be extracted by inverting a

combination of the monostatic and bistatic equations. That is, rather than requiring two complete radar installations, one site could contain both a transmitter and receiver while the second site need only have one of these. Thus, directional information would be available at a significantly reduced cost.

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PC.29

Characterization of Vertical Profiles and Column Amounts of Atmospheric Trace Gases Retrieved from Ground-Based Fourier-Transform InfraRed Spectrometer at Toronto, Canada

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A Bomem DA8 high-resolution Fourier-Transform InfraRed (FTIR) spectrometer (manufactured by ABB Bomem Inc., Québec, Canada) is the primary instrument at the University of Toronto Atmospheric Observatory (TAO). Continuous measurements of solar absorption spectra were started in October 2001. First vertical profiles and column amounts over Toronto were derived for CO, C_2H_6, HCN, CH_4, N_2O, NO_2, HCl, and HF from spectra measured during summer 2002. The essential advantage of the used technique is the simultaneous detection of information on a broad range of trace gases, which makes it very useful for the determination of changes in atmospheric composition, validation of model and satellite data.

An important aspect of data analysis is the characterization of the retrieved information, which complements the retrieved results and defines the knowledge of 'how the retrieval differs from the true state'. The study of this aspect of data analysis is very necessary for ground-based FTIR data retrievals taking into account the recent improvements in the forward models and retrieval algorithms (e. g. the evolution of SFIT-2 retrieval algorithm, NASA Langley Research Center).

Characterization of our retrievals was performed using an analysis based on the Rodgers formalism together with the error budget study. The vertical resolution of the retrieved profiles was estimated and the appropriate altitude ranges for partial column amounts were derived for the compounds studied. Those results will be presented.

PC.30

On the Interpretation of the MOPITT-measured Carbon Monoxide (CO) Distribution in the Troposphere

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The MOPITT (Measurements of Pollution In The Troposphere) instrument is an infrared radiometer aboard the NASA Terra Spacecraft, which was launched on Dec 18, 1999 and has been operating successfully since then. The MOPITT instrument has produced more than 3 years of carbon monoxide (CO) data. In this study we analyzed the "validated" version of CO data from March 2000 to May 2001. The CO distribution is described in terms of multi-layer maps for studying spatial patterns at

different seasons, as well as time-longitude, time-latitude and time-altitude sections for studying the transport behavior. MOPITT utilizes an indirect technique to retrieve the CO concentration from the measured radiance. The nature of the retrieval is best characterized in terms of the averaging kernel, as well as the "a priori" knowledge of the CO distribution. The detailed information of these parameters is also contained in the data set. By incorporating this information we conducted a data quality analysis and provide interpretations of the retrieved CO regarding day/night difference and land/sea differences.

PC.31

A Gas-Filter Correlation Radiometer for Remote Sensing of the Atmospheric CO2 Column

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Concern about the climatic effects of anthropogenic emissions of CO_2 has resulted in a growing need, both scientifically and politically, to monitor atmospheric CO_2. The development of a satellite instrument which could measure the global distribution of atmospheric CO_2 would greatly improve our understanding of the global carbon cycle and provide a means of monitoring regional sources and sinks.

In this presentation, we propose and analyse the potential of a nadir-viewing, satellite-based remote sounding instrument to globally measure the atmospheric CO_2 column. This instrument consists of Gas-Filter Correlations Radiometers (GFCR) tuned to the 6300 cm^{-1} (1.6 µm) and 5000 cm^{-1} (2 µm) regions. Although the design of such an instrument would present some engineering challenges, the proposed instrument has significant potential. Such an instrument should be able to measure the atmospheric CO_2 column to a precision better than 1 ppmv.

PC.32

A Model to Calculate what a Remote Sensor 'Sees' of an Urban Surface

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Whilst the measurement of radiation emissions from a surface is relatively straightforward, correct interpretation and proper utilization of the information requires that the surface area 'seen' be known accurately. This becomes non-trivial when the target is an urban surface due to its complex three-dimensional form and the different thermal, radiative and moisture properties of its myriad surface facets. The geometric structure creates shade patterns in combination with the solar beam and obscures portions of the surface from the sensor depending on where it is pointing and its field-of-view (FOV). A model to calculate these surface-sensor-sun relations (SUM) is described. SUM is tested against field, scale model and theoretical data and found to perform well. It can predict the surface area 'seen' by a sensor of known FOV pointing in any direction when placed at any point in space above a specified urban surface structure. Moreover, SUM can predict the view factors of the roof, wall and ground facets 'seen' and whether they are sunlit or shaded at any location and time of day. SUM can be used to determine the optimal placement and orientation of remote sensors to study urban radiation emissions, if the facet temperatures are known or modeled it can calculate the average temperature of the system, and it can determine the directional variation of temperature (anisotropy) due to any particular surface-sensor-sun geometric combination. The present surface geometry used in SUM is relatively simple, but there is scope to make it increasingly realistic.

PC.33

Observing Large-Scale Coherence of Geophysical Flows using Oblique Time-Lapse Photography

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The often rather smooth pictures of estuarine characteristics that result from temperature and salinity observations contrast with the almost invariably complex and « noisy » time series that are produced from current observations and yet both are aspects of the same system. Although the « noise » is often ascribed to turbulence it may in many cases result from flow features which are rapidly evolving in time but still coherent in some way over large spatial scales. One classic example would be relatively closely spaced sets of mooring observations in a field of almost parallel internal wave crests. In at least some estuarine environments these internal motions generate a recognizable surface manifestation in the form of rough and smooth patches of water which can easily be seen at highly oblique view angles. A system for observing the existence of temporal evolution of these features over scales of minutes to hours using digital oblique time-lapse still photography is described, and some results showing a variety of rapidly evolving but spatially coherent flow features are presented.

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