Program and Abstracts
Programme et Résumés

38th Congress of the
Canadian Meteorological and Oceanographic Society

38ième Congrès de la
Société canadienne de météorologie et d'océanographie

Human Dimensions of Weather and Climate
La dimension humaine de la météo et du climat

31 May - 03 June 2004 / 31 mai - 03 juin 2004
Edmonton, Alberta, Canada

Canadian Meteorological and Oceanographic Society

La Société canadienne de météorologie et d'océanographie

38th CMOS Congress / 38ième Congrès de la SCMO
31 May–03 June / 31 mai–03 juin, 2004
Edmonton, Alberta

Human Dimensions of Weather and Climate
La dimension humaine de la météo et du climat

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***The Edmonton Tornado** – July 1987* (courtesy Bob Charlton, *dec*., University of Alberta, Edmonton, AB)
***Tornado à Edmonton** – juillet 1987*

Gulf of Alaska storm (courtesy Howard Freeland, DFO/MPO, Sidney, BC)
Tempête dans le golfe d'Alaska

***Prairie drought** – 1997-2004* (unknown)
***Sécheresse dans les Prairies** - 1997-2004*

***Saguenay flood** – July 1996* (courtesy La Maison de la Presse, QC)
***Inondation au Saguenay** – juillet 1996*

***Red River flood** – April 1997* (unknown)
***Inondation de la rivière Rouge** – avril 1997*

***Québec Ice Storm** – January 1998* (courtesy Martin Chamberland, La Presse, QC)
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***Badger Flood** – February 2003* (courtesy Daniel Huang, Gander, NL)
***Inondation à Badger** – février 2003*

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May 2004

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A Word from our President
Un mot de notre président

On behalf of CMOS, I would like to welcome you to the 38th annual CMOS Congress. The congress is an important annual event that allows hydrologists, meteorologists and oceanographers from across the country to come together to share our ideas and knowledge, to plan and co-ordinate our programs, to renew old friendships and to make new ones and to honour the accomplishments of our colleagues.

CMOS and CMOS Congresses would not exist if it were not for the efforts of many members both locally and across the country. This Congress is the culmination of more than a year's planning by the Local Arrangements Committee led by Brian Paruk and the Scientific Planning Committee led by Geoff Strong. Europeans first established Edmonton in 1795 as a major trading post. West Edmonton mall can be seen as the continuation of that heritage. On behalf of CMOS, I would like to thank all the many volunteers of the Alberta centre for creating this wonderful meeting in this uniquely Edmonton venue.

We have come to Edmonton from the East, the West, the South and the North. I welcome you to this Congress to trade your knowledge, ideas, plans and dreams so that we can enrich our community of Canadian hydrologists, meteorologists and oceanographers so that we can better serve Canadians and the Earth.

Best wishes to all for an exciting and productive Congress in Edmonton

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Au nom de la SCMO, il me fait grand plaisir de vous souhaiter la bienvenue au 38ième congrès annuel. Le congrès est un événement annuel de première importance qui permet aux hydrologues, météorologues et océanographes de partout au pays de se rencontrer pour partager des idées et des connaissances, planifier et coordonner leurs programmes respectifs, fraterniser entre amis et connaissances et souligner les accomplissements de collègues.

Sans les efforts déployés par un grand nombre de membres tant au niveau local qu'au plan national, la SCMO et son congrès annuel n'existeraient tout simplement pas. Le congrès de cette années est l'aboutissement de plus d'un an de travaux préparatoires par le comité organisateur local dirigé par Brian Paruk et le comité du programme scientifique dirigé par Geoff Strong. La ville d'Edmonton fut établie en 1795 par des Européens qui en firent un poste de traite important. Le centre commercial West Edmonton où se tiendra le congrès peut être vu comme un digne prolongement de ce premier poste historique. Je voudrais remercier au nom de la SCMO les nombreux bénévoles du Centre de l'Alberta qui ont mis sur pied une si remarquable conférence en un site tout à fait unique de la ville d'Edmonton.

Nous sommes venus à Edmonton des quatre points cardinaux. Il me fait plaisir de vous accueillir à ce congrès au cours duquel vous aurez l'occasion d'échanger et de partager vos connaissances, vos idées et vos rêves et ainsi enrichir la communauté canadienne d'hydrologues, de météorologues et d'océanographes au service de la population canadienne et du monde entier.

J'offre à tous mes meilleurs vœux en formulant le souhait que ce congrès d'Edmonton soit des plus excitant et productif.

Allyn Clarke
President, CMOS
Président, SCMO
2003-2004

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Quelques mots à propos de la Société
A Word about the Society

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 1'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 1'atelier "Project Atmosphere" de I'AMS/NOAA, la bourse de troisième cycle "Weather Research House/SCMO/CRSNG", des bourse aux étudiants sous gradués, et depuis peu, le Prix Campbell Scientific pour la meilleure présentation sur poster, et la bourse SCMO/MétéoMédia.

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 1'enseignement de la météorologie et de l'océanographie au Canada. Il y a maintenant une section dévouée au secteur privé où on énumère les compagnies et leurs services.

La Société utilise maintenant le logiciel Association Management Software (AMSoft) pour administrer ses membres et abonnés. On a aussi acheté des logiciels pour permettre aux membres de mettre eux-mêmes à jour leur dossier, selon le besoin.

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

CMOS
SCMO

La Société canadienne de météorologie et d'océanographie
Canadian Meteorological and Oceanographic 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 most recently, the Campbell Scientific Prize for the best poster presentation at a Congress and the CMOS Weather Network Scholarship.

The main publications of CMOS are the bimonthly CMOS Bulletin SCMO and ATMOSPHERE-OCEAN (A-O), a quarterly refereed journal for the publication of results of original research. The Society also maintains an electronic Web site, with information on the Society and its activities pertaining to meteorological and oceanographic activities across Canada. There is now a special section devoted to the Private Sector where companies and services are now listed.

CMOS is now using Association Management Software (AMSoft) for its membership and subscription functions. Additional software has been purchased in order to allow members and centres to amend and update their own respective files as the need arises.

For additional information visit the CMOS web site at http://www.cmos.ca

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

CMOS
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A Word from the Chair of the Science Program Committee
Un mot du président du comité scientifique

The Science Program Committee (SPC) and CMOS Alberta Centre are pleased to welcome you to the 38th Annual CMOS Congress here in Edmonton. The theme of this Congress, *Human Dimensions of Weather and Climate*, is very appropriate at this time. Never before has society in general, and our Society in particular, been so focused on the complexities of human interactions on and by our environment. Mankind has become a significant force of nature, and we are all part of an inadvertent experiment on the environment of planet Earth, one where we do not yet understand the full extent of the impacts. These are therefore exciting and important times, where CMOS must reach beyond our traditional fields of meteorology, oceanography, hydrology, and climatology. The fact that we have plenary presentations from the fields of medicine, natural hazards, and space science, alongside traditional atmospheric and oceanographic talks, speaks volumes for how CMOS is promoting inter-disciplinary science in Canada. The SPC made extra effort to encourage our oceanography colleagues to this inland prairie location, and also gave special emphases to related disciplines such as hydrology, thereby highlighting the combined importance of all three aspects of the hydrological cycle so essential to all our disciplines. The many sessions devoted to climate and climate change (6 sessions), weather-health issues (3), hazardous weather (7), drought and water issues (2), sea-level rise impacts (1), high-latitude processes and MAGS (3 sessions), all attest to our concern for the *human dimensions of* our *weather and climate*. We acknowledge the volunteer efforts of members of our Science Program and Local Arrangements Committees, and the great job that Yvonne Wilkinson did on assimilating this program book. Special recognition goes to volunteers who have no vested interest in our sciences, but just wanted to 'help out', including Randy Pakan who designed our poster, Laura Smith (Secretary), and many students who are assisting during Congress week. We hope that this 38th Congress will be enjoyable and fruitful for all, and will foster some of the necessary contacts and interactions that will contribute to our understanding of this giant experiment on our planet Earth.

C'est avec grand plaisir que le comité du programme scientifique (CPS) et le Centre de l'Alberta de la SCMO vous accueillent au 38e congrès annuel de la SCMO ici à Edmonton. Nous croyons que le thème de ce congrès, *La dimension humaine de la météo et du climat*, est des plus approprié. Jamais la société en général, et notre Société en particulier, n'ont porté autant d'attention aux complexités des interactions humaines et à l'environnement que maintenant. Par leur comportement, les humains constituent une force importante de la nature et tous, tant que nous sommes, nous participons malgré nous à une expérience sur l'environnement et la planète terre dont nous ne soupçonnons même pas toutes les conséquences. Il faut dès lors constater que nous vivons à une époque charnière de l'histoire humaine, ce qui nous force, nous de la SCMO, à étendre notre champ d'action au-delà de nos domaines traditionnels de météorologie, d'océanographie, d'hydrologie et de climatologie. Le fait que les conférenciers de nos plénières proviennent de disciplines aussi diverses que la médecine, les catastrophes naturelles et les sciences spatiales tout autant que de celles plus traditionnelles de la météorologie et de l'océanographie montre bien comment la SCMO entend encourager l'interdisciplinarité de la science au Canada. Le CPS s'est employé de façon particulière à attirer ici, en pleine prairie, nos collègues en océanographie et a donné beaucoup d'importance à des disciplines connexes telle l'hydrologie, mettant ainsi en relief l'importance conjuguée des trois aspects du cycle hydrologique si essentiels à toutes nos disciplines. Les nombreuses sessions consacrées au climat et au changement climatique (6 sessions), aux questions reliant la santé et la météo (3), aux conditions météorologiques à risque (7), aux questions concernant la sécheresse et l'eau (2), aux conséquences de la hausse du niveau de la mer (1), aux processus en haute latitude et à MAGS (3 sessions) attestent de nos préoccupations vis-à-vis *la dimension humaine de la météo et du climat*. Nous reconnaissons les efforts fournis bénévolement par les membres de notre comité du programme scientifique ainsi que par ceux du comité organisateur local, et le bon travail par Yvonne Wilkinson avec l'assimilation de ce programme livre. Il me faut souligner de façon toute particulière le travail de nombreux bénévoles qui, n'ayant aucun intérêt direct dans nos activités scientifiques, ont voulu quand même «seulement nous aider», y compris Randy Pakan, le concepteur de notre affiche, Laura Smith (secrétaire) ainsi que plusieurs étudiants et étudiantes qui nous fournissent assistance tout au long de la semaine du congrès. Nous espérons que ce 38ième congrès sera agréable et fructueux et qu'il nous fournira l'occasion de nouer des contacts et de susciter des interactions susceptibles de nous permettre de mieux comprendre notre implication dans cette gigantesque expérience menée sur la planète terre.

Geoff Strong
Chair, Science Program Committee
Président du comité du programme scientifique

On behalf of the Local Arrangements Committee, I would like to extend a warm welcome to the participants in the 2004 CMOS Congress. I hope you will find much in the way of new material, inspiration, and innovation.
I hope you will take away many new contacts, and renewed enthusiasm.

I'd like to extend a special thank you to Dr. Geoff Strong and his Science Program Committee for developing the Congress program. As well, I'd like to thank my Local Arrangements Committee, whose hard work over the past two years has made it all possible. And, of course, special thanks must go to everyone who submitted their work for a session or poster.

This is a beautiful time of year in Edmonton, and I do hope you will get out and enjoy the prairie spring weather as well as Congress sessions. Once again, welcome to Edmonton.

Au nom du comité organisateur local, j'aimerais souhaiter la plus cordiale bienvenue à tous les participants au congrès 2004 de la SCMO. J'espère que ce sera pour vous l'occasion de prendre connaissance de choses à la fois nouvelles, inspirantes et innovatrices, d'établir de nouveaux contacts et de renouveler votre enthousiasme.

Je tiens à exprimer ma gratitude à Geoff Strong et à son comité du programme scientifique pour le formidable travail qu'ils ont accompli. Je me dois également de remercier les membres de mon comité organisateur local qui ont travaillé sans relâche depuis plus de deux ans à organiser cet événement. Et, bien entendu, je remercie chaleureusement tous ceux et celles qui ont présenté des travaux pour les sessions orales et d'affiches.

Le temps est magnifique à Edmonton à ce temps-ci de l'année. En participant au congrès, vous profiterez tout autant de la clémence du printemps dans les prairies que de sessions scientifiques enrichissantes.

Brian Paruk
Chair, Edmonton Local Arrangements Committee
Président du comité organisateur local d'Edmonton

Informations et événements sociaux
Information and Social Events

Inscription et renseignements
Le poste pour l'inscription est situé au premier étage de l'hôtel Fantasyland, voisin de la salle de bal, entre les escaliers et les ascenseurs. Il sera ouvert aux heures suivantes:

dimanche 30 mai	1200 – 1700
lundi 31 mai	0730 – 1700
mardi 01 juin	0730 – 1700
mercredi 02 juin	0730 – 1700
jeudi 03 juin	0730 – 1300

Un service d'accueil sera disponible chaque jour au poste d'inscription. On peut également s'y procurer des billets d'entrée et des coupons supplémentaires pour les événements sociaux.

Salles pour le congrès
Les différentes sessions seront tenues dans la salle de bal principale C/D de même que dans les salons Piesporter, Medeira, Bordeaux, Beaujolais et Chablis.

Services informatiques
Pour l'accès à Internet et les autres besoins en informatique, des ordinateurs seront disponibles dans le salon Champagne; un service de graveur sur CD-ROM pour ordinateurs de type PC sera disponible pour les présentations Power Point:

lundi 31 mai	1200 – 1700
mardi 01 juin	0800 – 1700
mercredi 02 juin	0800 – 1700
jeudi 03 juin	0800 – 1300

Babillard
Un babillard sera installé dans le salon Champagne afin de permettre aux congressistes de recevoir des messages d'autres congressistes ou de l'extérieur.

Sessions d'affiches
Des communications scientifiques sur affiches seront en montre dans la salle de bal A/B du lundi 31 mai à 17h30 au mercredi 02 juin à 12h. Cette session sera également ouverte aux congressistes durant le cocktail de bienvenue le lundi soir.

Cocktail de bienvenue
La firme Campbell Scientific Inc. est heureuse de commanditer ce cocktail de bienvenue. Tous les congressistes sont invités à venir y déguster un goûter léger et des consommations dans la salle de bal C/D à 18h le lundi 31 mai. La pochette d'inscription contient un coupon d'entrée pour ce cocktail, lequel donne également droit à une consommation gratuite au bar. Les congressistes qui voudront des consommations additionnelles pourront se les procurer à leurs frais au bar. Il sera possible de se procurer des billets de participation supplémentaires pour ce cocktail au poste d'inscription.

Dîner des récompenses
Ce repas sera servi dans la salle de bal C/D le mardi 1er juin de midi à 14h. Il sera possible de se procurer des billets de participation supplémentaires pour ce dîner au poste d'inscription.

Banquet
Le banquet annuel du congrès se tiendra dans la salle de bal C/D le mercredi 02 juin. Les apéritifs seront servis à compter de 18h00 et le dîner servi à 18h30. Prix et distinctions seront décernés à la fin du dîner, et le tout sera suivi d'une intéressante présentation par le naturaliste *Ben Gadd*.

Programme des partenaires
Quelques visites à des sites d'intérêt local seront offertes aux congressistes. Ceux et celles qui voudront participer à ces visites pourront inscrire leurs noms sur des feuilles d'inscription placées au poste d'inscription. Pour certaines de ces visites, des frais pourront s'appliquer.

Registration and Information Desk
The Registration Desk is located on the second floor of the Fantasyland Hotel, adjacent to the Ballroom, between the stairs and the elevators. It will be open:

Sunday, May 30	1200 – 1700
Monday, May 31	0730 – 1700
Tuesday, June 01	0730 – 1700
Wednesday, June 02	0730 – 1700
Thursday, June 03	0730 – 1300

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

Congress Rooms
Congress sessions will be held in the main Ballroom, Piesporter, Medeira, Bordeaux, Beaujolais, and Chablis rooms.

Computer Services
For Internet access and other computer needs of the participants, computers will be available in the Champagne room; a CD_ROM burning service for PC-type computers will be available for PowerPoint presentations.

Monday, May 31	1200 – 1700
Tuesday, June 01	0800 – 1700
Wednesday, June 02	0800 – 1700
Thursday, June 03	0800 – 1300

Message Board
A message board will be available in the Champagne 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 Ballrooms A/B from 1730 Monday, 31 May to 1200 noon Wednesday, 02 June. Formal poster presentations will be during the Icebreaker on Monday evening, 31 May, from 1730 to 1900.

Icebreaker
The Congress Icebreaker is proudly sponsored by Campbell Scientific Inc. All participants are invited for food and refreshments at 1800 on Monday, 31 May in Ballrooms C/D. 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 afterward. Extra tickets can be purchased at the Registration Desk.

Awards Luncheon
The Awards Luncheon will be served in Ballrooms C/D on Tuesday, 01 June from 1200 to 1400. Extra tickets can be purchased at the Registration Desk.

Banquet
The annual Congress Banquet will be held in Ballrooms C/D on Wednesday, 02 June. Cocktails will begin at 1800 and dinner will be served at 1830. Additional awards will be presented at the end of dinner, and they will be followed by a very interesting presentation by naturalist *Ben Gadd*.

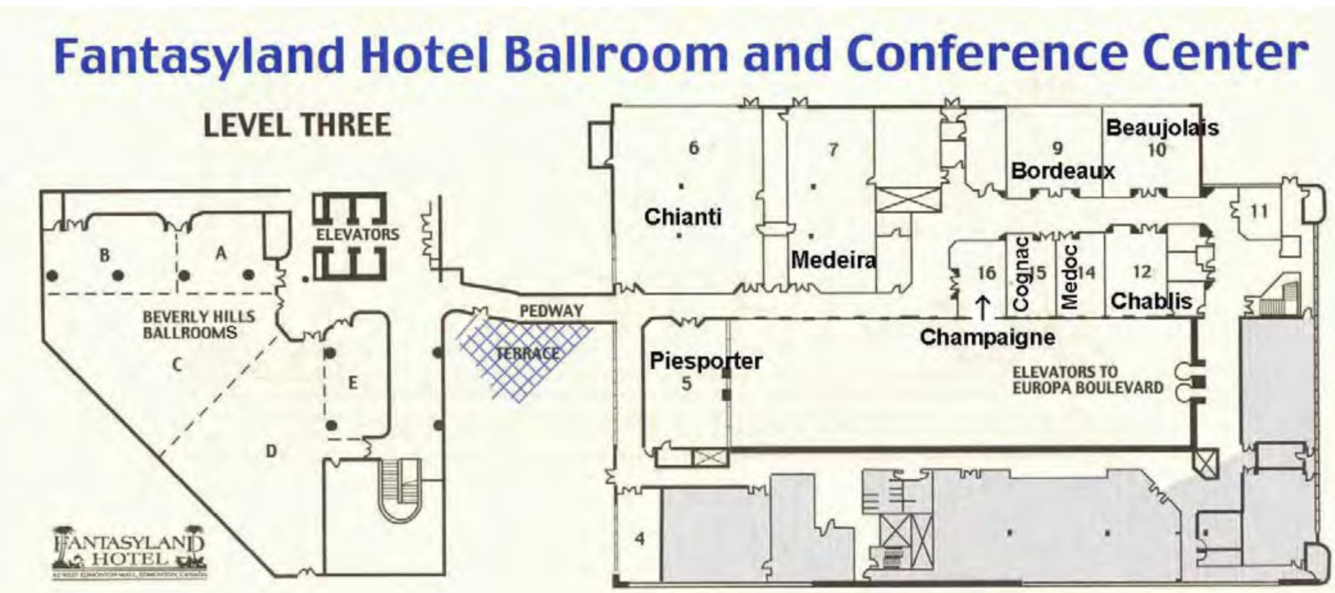
Partners Program
A couple of tours to local sites of interest will be provided. Sign-up sheets will be provided at the Registration Desk. Some entrance fees may be required.

Local Arrangements Committee
Comité organisateur local

Brian Paruk, Chair
GS Strong, SPC
John Dublin, Audio visual
John Powell, Food
John Wilson, Secretary
Oscar Koren, Exhibits
Claude Lebine, Exhibits
Mitch Makowsky, Exhibits
Curtis Mooney, Publicity
Sandra Buzza, Partners
Edward Hudson, Treasurer
Glyn Smith, Registration
Ex-Officio Member, *Neil Campbell*

Scientific Program Committee
Comité du programme scientifique

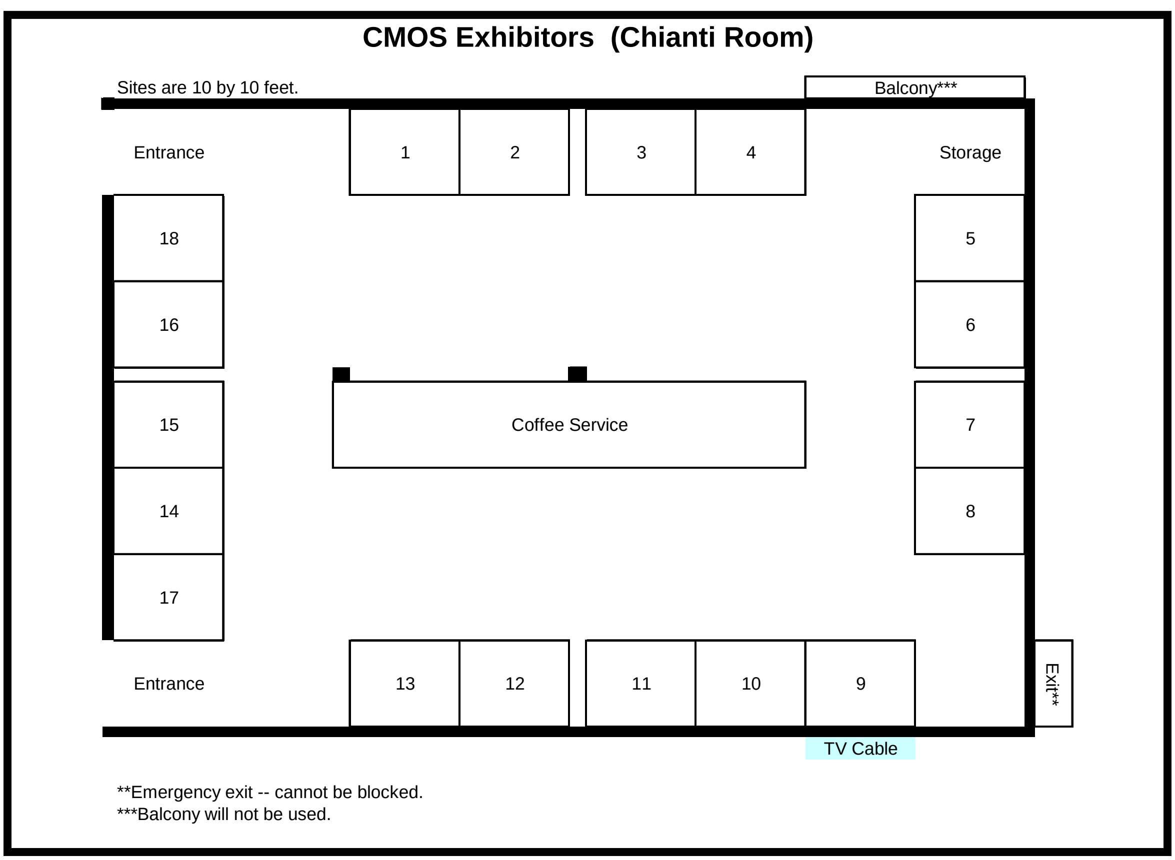
GS Strong, Chair
Paul Myers, Web page
Laura Smith, Secretary
Steve Ricketts
Bob Kochtubajda
Dick Stoddart
Ed Hudson
Ed Lozowski
Terry Krauss
Brian Paruk, LAC
Ex-Officio Member, *Neil Campbell*



CMOS Congress Rooms / Chambres de congrès SCMO

A/B Ballrooms – *Poster Session*
C/D Ballrooms – *Plenary* and *Major Sessions; Icebreaker; Awards Luncheon; Banquet*
5, **Piesporter**; 7, **Medeira**; 9, **Bordeaux**; 10, **Beaujolais**; 12, **Chablis** – *Scientific Sessions*
6, **Chianti** – *Exhibits* and *Coffee Stations*
14, **Medoc**; 15, **Cognac** – *Sunday Meetings*
16, **Champaigne** – *Congress Office* and *Computer Room*

Booth	Exhibitors / Exposants	Sponsors / Commanditaires
1	Canadian Ice Service, MSC	ProSensing Inc.
2	Meteorological Service of Canada, Toronto	John Willey & Sons LTD
3	COMET/UCAR	York University
4	Hoskin Scientific Limited	Vaisala
5	Radiometrics Corporation	
6	DEGREANE	
7	Weather Decision Technologies	
8	Info-Electronics Systems Inc	
9	Weather Network	
10	Meteorological Service of Canada, Atlantic	
11	AXYS Environmental Systems	
12	Campbell Scientific	
13	Campbell Scientific	
14	Canadian Foundation for Climate & Atmospheric Sciences (CFCAS)	
15	Mackenzie GEWEX Study	
16	Vaisala	
17	CMOS	
18	University of Alberta	



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- Inverted Troughs Webcast
- De mm à cm... Étude des rapports neige/eau liquide au Québec

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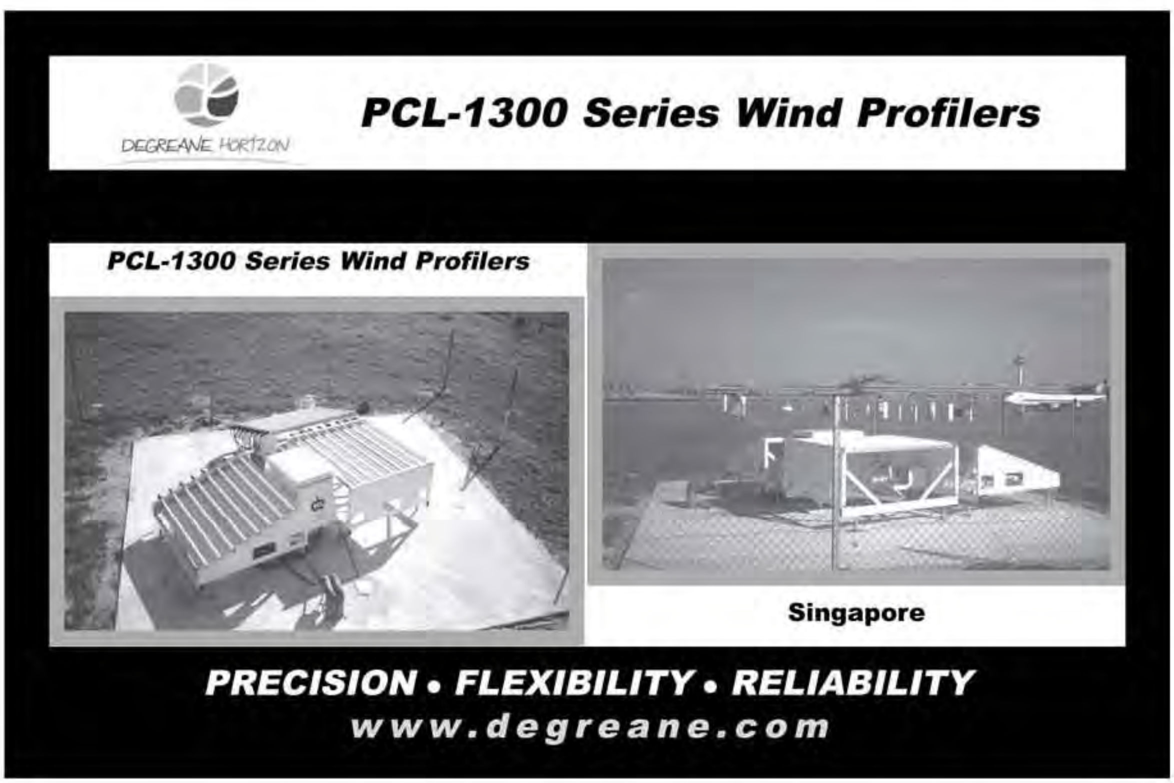
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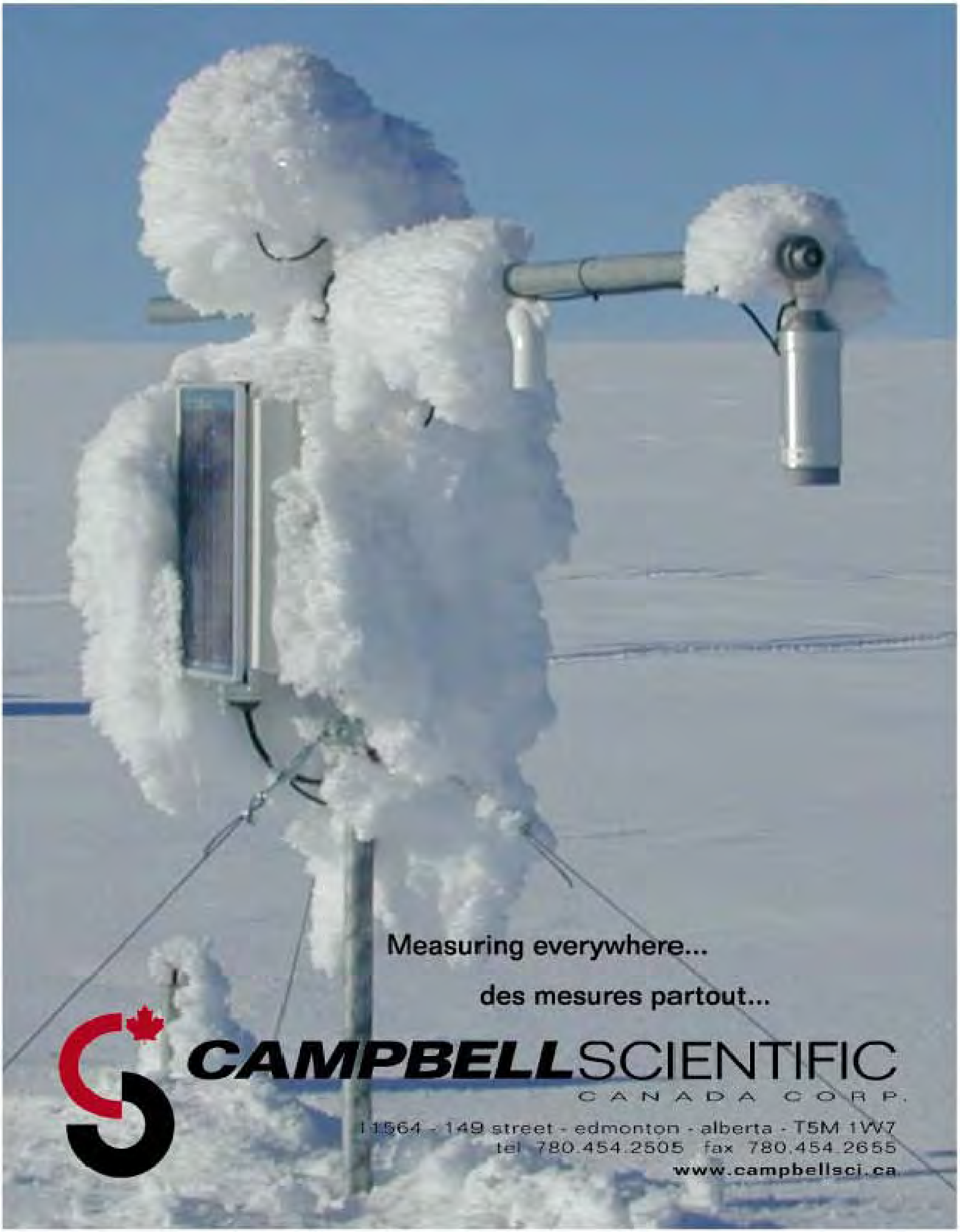
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Certificate Programs: The Department offers a Certificate in Meteorology recognized by the Meteorological Service of Canada as satisfying one of their entrance requirements as a meteorologist. We also offer a Certificate in Geographic Information Systems (GIS) and Remote Sensing.

Jobs / Internships: Many undergraduate students find summer jobs or internships with department research programs, the Meteorological Service of Canada (MSC) or The Weather Network (TWN). Recent graduates have been hired as forecasters by MSC, OME and TWN while many continue their meteorological education as graduate students, both at York and elsewhere (McGill and U. of Manitoba are recent examples).

Research / Graduate Studies: Research and teaching activities span a range of topics from aerosol chemistry, cloud microphysics and small scale turbulence, through micro-, meso- and synoptic-scale meteorology to global scale phenomena affecting weather and climate, on Earth and Mars. Numerical modelling plays a central role in many of the research studies, but field projects are also conducted, including participation in Arctic projects.

There are excellent opportunities for collaborative research, especially with the Meteorological Service of Canada. Students interested in graduate studies in Earth, Space and Atmospheric Science may apply through the Centre for Research in Earth and Space Science (CRESS).

Department of Earth and Space Science and
Engineering, Faculty of Pure and Applied Science, York University, 4700 Keele St., Toronto, ON, M3J 1P3
Tel: 416-736-5245; Fax: 416-736-5817
Email: esse@yorku.ca
Websites: www.yorku.ca/esse **/** www.cress.yorku.ca

CMOS Congress Bursary Recipients – 2004:

No.	Name	University/Location
1	*Frédéric Bouchard*	Université Laval, Quebec City, QC, Canada
2	*Anne-Sophie Cochelin*	McGill University, Montréal, QC, Canada
3	*Farida Dehghan*	York University, Toronto, ON, Canada
4	*Geoff Doerksen*	University of British Columbia, Vancouver, BC, Canada
5	*Christopher T Fogarty*	Dalhousie University, Halifax, NS, Canada
6	*Xiaojing Jia*	McGill University, Montréal, QC, Canada
7	*Jennifer Lilly*	McGill University, Montréal, QC, Canada
8	*Cristina Lupu*	Université du Québec à Montréal, QC, Canada
9	*Yosvany Martinez*	McGill University, Montréal, QC, Canada
10	*Iriola Mati*	McGill University, Montréal, QC, Canada
11	*Douglas G Mercer*	Dalhousie University, Halifax, NS, Canada
12	*Brian Papa*	McGill University, Montréal, QC, Canada
13	*Steven M Quiring*	University of Delaware, Newark, DE, USA
14	*Erin Roberts*	McGill University, Montréal, QC, Canada
15	*Kyle Spyksma*	McGill University, Montréal, QC, Canada
16	*Julie Theriault*	McGill University, Montréal, QC, Canada
17	*James E Valcour*	University of Guelph, Guelph, ON, Canada
18	*Marjolijn van der Hoek*	University of Western Ontario, London, ON, Canada
19	*Cindy Walsh*	University of British Columbia, Vancouver, BC, Canada
20	*Xingbao Wang*	McGill University, Montréal, QC, Canada
21	*Yi Wang*	McGill University, Montréal, QC, Canada
22	*Amy Waterhouse*	University of British Columbia, Vancouver, BC, Canada
23	*Andrew M Way*	McGill University, Montréal, QC, Canada

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1	*Victoria Hoyle*	University of Calgary, Calgary, AB, Canada
2	*Natalya Nicholson*	University of Calgary, Calgary, AB, Canada

Meetings Scheduled throughout Congress Week:

Day/Date – Group	Chair	Room (No.)	Time
Sunday/dimanche, 30 May/mai			
▪ Private Sector Committee	Susan Woodbury	Cognac (15)	09:00-11:00
▪ Scientific Committee on Oceanic Research (SCOR)	Dick Stoddart	Bordeaux (9)	09:00-14:00
▪ Publications Committee	Steve Lambert	Medoc (14)	09:30-12:00
Lunch			**12:00-13:00**
▪ Science Committee (SciCom) Meeting	Ken Denman	Chablis (12)	13:00-15:00
▪ University & Professional Education Committee	Peter Bartello	Medoc (14)	13:00-14:00
▪ School & Public Education Committee (SPEC)	Gilles Simard	Medoc (14)	14:00-15:00
▪ Fellows Committee	Ron Bianchi	Beaujolais (10)	14:00-15:00
▪ External Relations Committee	Allyn Clarke	Cognac (15)	14:00-15:00
Health Break			**15:00-15:30**
▪ Nominating Committee	Harold Ritchie	Chablis (12)	15:30-16:30
▪ Membership Committee	Ron Bianchi	Medoc (14)	15:30-16:00
▪ Centre Chairs Meeting	Allyn Clarke	Medoc (14)	16:00-16:30
▪ CFCAS	Gordon McBean	Beaujolais (10)	16:30-17:30
▪ CMOS Council Meeting	Allyn Clarke	Beaujolais (10)	17:30-19:00
Monday/lundi, 31 May/mai			
▪ UNSTABLE Working Group Meeting	Geoff Strong	Chablis (12)	17:30-18:30
▪ POSTER SESSION	Claude Labine	Ballrooms A/B	17:30-19:00
▪ ICEBREAKER	Claude Labine	Ballrooms C/D	18:00-19:30
Tuesday/mardi, 01 June/juin			
▪ CMOS Awards Luncheon	MC-Ed Lozowski	Ballrooms C/D	12:00-14:00
▪ CMOS Annual General Meeting	Allyn Clarke	Ballrooms C/D	19:30-21:30
Wednesday/mercredi, 02 June/juin			
▪ Cocktails		Ballrooms C/D	18:00-18:30
▪ Banquet (Spkr: ***Ben Gadd***, Naturalist)	MC-Ed Hudson	Ballrooms C/D	18:30-21:00

Mary Ann Cooper Department of Emergency Medicine, University of Illinois at Chicago, ILL, USA *and* Fellow of the American Meteorological Society Contact: macooper@uic.edu ***"Struck by Lightning: A Lifelong Sentence"***	Monday, 31 May 09:00-09:45 1-A.1
Gordon A McBean Institute for Catastrophic Loss Reduction, Departments of Geography and Political Science, University of Western Ontario, London, ON, Canada Contact: gmcbean@uwo.ca ***"Climate Change: How it Will Affect Natural Hazards"***	Monday, 31 May 09:45-10:30 1-A.2
Virendra Jha Vice-President Science, Technology and Programs, Canadian Space Agency, Saint-Hubert, QC, Canada Contact: virendra.jha@space.gc.ca ***"Remote-Sensing and New Technologies: a New Era"*** ***"La télédétection et les technologies d'Àvant-garde: une ère nouvelle"***	Tuesday, 01 June 08:35-09:20 2-A.1
Dale B Haidvogel Rutgers University, NJ, USA Contact: dale@marine.rutgers.edu ***"Ocean Modeling using Mixed Spectral/Finite Element/Finite Volume Methods"***	Tuesday, 01 June 09:20-10:05 2-A.2
Vice Admiral Conrad C Lautenbacher, Jr, US Navy (Ret.) Undersecretary of Commerce for Oceans and Atmosphere *and* NOAA Administrator, U.S. Department of Commerce, Washington, DC, USA Contact: Carla.Sullivan@noaa.gov ***"Stewardship of our Earth Resources through a Comprehensive, Coordinated and Sustained Global Observation System"***	Wednesday, 02 June 08:35-09:20 3-A.1
Eddy Carmack Institute of Ocean Sciences, Department of Fisheries and Oceans, Sidney, BC, Canada Contact: carmacke@dfo-mpo.gc.ca ***"Canada's Northern Oceans: Connectivity, Mechanics and Human Ties"***	Wednesday, 02 June 09:20-10:05 3-A.2
Jim Abraham Director, Meteorological Service of Canada (MSC), Downsview, ON, Canada Contact: jim.abraham@ec.gc.ca ***"Hurricanes in Canada: the Threat, the Impacts, Forecast and Research Challenges"***	Thursday, 03 June 08:35-09:20 4-A.1
T Andrew Black Faculty of Agricultural Sciences, University of British Columbia, Vancouver, BC, Canada Contact: andrew.black@ubc.ca ***"Micrometeorology and Carbon Balance Research in Northern Forests"***	Thursday, 03 June 09:20-10:05 4-A.2

Week at a glance
Aperçu de semaine

Room/salle	Time/heures	*Day 1 / jour 1* Monday/lundi 31 May/mai	Time/heures	*Day 2 / jour 2* Tuesday/mardi 01 June/juin
C/D Ballrooms	**08:30-09:00**	**Welcome and Introductions**	**08:30-08:35**	**Announcements**
C/D Ballrooms	**09:00-10:30**	**1-A: Plenary Session** *(Geoff Strong)*	**08:35-10:05**	**2-A: Plenary Session** *(Paul Myers)*
C/D Ballrooms		***– Mary Ann Cooper*, MD** Department of Emergency Medicine, University of Illinois at Chicago *and* Fellow of the American Meteorological Society		***– Virendra Jha*, Vice-President** Canadian Space Agency Saint-Hubert, Quebec
C/D Ballrooms		***– Gordon McBean*** Institute for Catastrophic Loss Reduction, University of Western Ontario		***– Dale B Haidvogel*** Rutgers University, New Jersey, USA
	10:30-11:00	**HEALTH BREAK**	**10:05-11:00**	**HEALTH BREAK**
C/D Ballrooms	**11:00-12:30**	**1-B-1:** ***Health Issues in Weather and Climate I*** *(Denis Bourque)*	**10:30-12:00**	
5–Piesporter	**11:00-12:30**	**1-B-2:** ***Climate Change I – Modelling & Paleoclimate*** *(Andy Bush)*	**10:30-12:00**	**2-B-1:** ***Future Role of Operational Meteorology*** *(Jim Abraham)*
7–Medeira	**11:00-12:30**	**1-B-3:** ***Air-Sea Interactions & Waves I*** *(Bridget Thomas)*	**10:30-12:00**	**2-B-2:** ***Remote Sensing I – Satellite*** *(Enrico Torlaschi)*
9–Bordeaux	**11:00-12:30**	**1-B-4:** ***Aviation Meteorology I – Verification and Data*** *(Steve Ricketts)*	**10:30-12:00**	**2-B-3:** ***Basin to Global Ocean Data Assimilation – II (****Keith Thompson)*
10–Beaujolais	**11:00-12:30**	**1-B-5:** ***Hazardous Weather I – Severe Convective Processes*** *(Dave Sills)*	**10:30-12:00**	2-**B-4:** ***MAGS Special Session – Toward a Deeper Understanding of the Regional Climate of Northwest Canada I*** *(Hok Woo)*
12–Chablis	**11:00-12:30**		**10:30-12:00**	**2-B-5:** ***Cloud Physics*** *(Ed Lozowski)*
	12:30-14:00	**LUNCH**	**12:00-14:00**	**CMOS Awards Luncheon**
C/D Ballrooms	**14:00-15:30**	**1-C-1:** ***Health Issues in Weather and Climate II*** *(Denis Bourque)*		
5–Piesporter	**14:00-15:30**	**1-C-2:** ***Sea-Level Rise Impacts*** *(Hal Ritchie)*	**14:00-15:30**	**2-C-1:** ***Aviation Meteorology III – Forecast Techniques*** *(Steve Ricketts)*
7–Medeira	**14:00-15:30**	**1-C-3:** ***Climate Change II – Data and QC*** *(Steve Lambert)*	**14:00-15:30**	**2-C-2:** ***Remote Sensing II – Radar*** *(Paul Joe)*
9–Bordeaux	**14:00-15:30**	**1-C-4:** ***Aviation Meteorology II – Icing*** *(Stewart Cober)*	**14:00-15:30**	**2-C-3:** ***Regional Ocean Modelling*** *(Kim Schmidt)*
10–Beaujolais	**14:00-15:30**	**1-C-5:** ***Hazardous Weather II – Severe Convection Case Studies*** *(Geoff Strong)*	**14:00-15:30**	**2-C-4: MAGS Special Session –** ***Toward a Deeper Understanding of the Regional Climate of Northwest Canada II*** *(John Gyakum)*
12–Chablis	**14:00-15:30**		**14:00-15:30**	**2-C-5:** ***Statistical Climatology I*** *(Sam Shen)*
	15:30-16:00	**HEALTH BREAK**	**15:30-16:00**	**HEALTH BREAK**
C/D Ballrooms	**16:00-17:30**	**1-D-1:** ***Societal Implications of Weather and Climate*** *(Denis Bourque)*	**16:00-17:30**	**2-D-1:** ***Atmospheric Monitoring – Emerging Technologies*** *(Bob Kochtubajda)*
5–Piesporter	**16:00-17:30**	**1-D-2:** ***Basin to Global Ocean Data Assimilation I*** *(Keith Thompson)*	**16:00-17:30**	2-**D-2:** ***Hazardous Weather IV – Winter Storms*** *(Peter Bowyer)*
7–Medeira	**16:00-17:30**	**1-D-3:** ***High Latitude Processes*** *(Dan Kulak)*	**16:00-17:30**	**2-D-3:** ***Micro-Meteorology*** *(Claude Labine)*
9–Bordeaux	**16:00-17:30**	**1-D-4:** ***Prairie Drought/Water Issues I – joint CMOS/CGU Session*** *(Ron Stewart)*	**16:00-17:30**	**2-D-4:** ***Northern Oceans I*** *(Paul Myers)*
10–Beaujolais	**16:00-17:30**	**1-D-5:** ***Hazardous Weather III – Lightning and WildFires*** *(Bill Burrows)*	**16:00-17:30**	***MAGS - closed working group*** *(Hok Woo)*
12–Chablis	**17:30-18:30**	*UNSTABLE MEETING (Geoff Strong)*	**17:30-18:30**	***CLOSED MEETING***
A/B Ballrooms	**17:30-19:00**	**1-P-1:** ***POSTER SESSION*** *(Claude Labine)*		
C/D Ballrooms	**18:00-19:30**	***ICE BREAKER***	**19:30-21:30**	***CMOS AGM***

Room/salle	Time/heures	*Day 3 / jour 3* Wednesday/mercredi 02 June/juin	Time/heures	*Day 4 / jour 4* Thursday/jeudi 03 June/juin
C/D Ballrooms	**08:30-08:35**	**Announcements**	**08:30-08:35**	**Announcements**
C/D Ballrooms	**08:35-10:05**	**3-A: Plenary Session** *(Marc Denis Everell, Assistant Deputy Minister, MSC)*	**08:35-10:05**	**4-A:Plenary Session** *(Steve Ricketts)*
C/D Ballrooms		**– *Vice Admiral Conrad Lautenbacher***, Undersecretary of Commerce for Oceans & Atmosphere *and* NOAA Administrator		**– *Jim Abraham***, Director General MRB, Meteorological Service of Canada
C/D Ballrooms		**– *Eddy Carmack***, Institute of Ocean Sciences Department of Fisheries and Oceans, BC		**– *Andrew Black***, Faculty of Agricultural Sciences, University of British Columbia
	10:05-10:30	**HEALTH BREAK**	**10:05-10:30**	**HEALTH BREAK**
C/D Ballrooms	**10:30-12:00**	**3-B-1: *Climate Change III – Telecommunications*** *(K Andrew Peterson)*	**10:30-12:00**	**4-B-1: *Climate Change IV*** *(Phil Merilees)*
5–Piesporter	**10:30-12:00**	**3-B-2: *Hazardous Weather V – Emerging Forecasting Methodologies*** *(Neil Taylor)*	**10:30-12:00**	**4-B-2: *Canadian Community Model II*** *(Louis Lefaivre)*
7–Medeira	**10:30-12:00**	**3-B-3: *Northern Oceans II*** *(Howard Freeland)*	**10:30-12:00**	**4-B-3: *Geophysical Fluid Dynamics I*** *(Bruce Sutherland)*
9–Bordeaux	**10:30-12:00**	**3-B-4: *Remote Sensing IV GPS Measurement & Modelling of Atmospheric Moisture*** *(Susan Skone)*	**10:30-12:00**	**4-B-4: *Hazardous Weather VI – Tropical Cyclones & Hurricanes*** *(Jim Abraham)*
10–Beaujolais	**10:30-12:00**	**3-B-5: *MAGS Special Session – Toward a Deeper Understanding of the Regional Climate of Northwest Canada III*** *(Kit Szeto)*	**10:30-12:00**	**4-B-5: *Statistical Climatology*** *(Raymond Wong)*
12–Chablis	**10:30-12:00**	**3-B-6: *Building Meteorological & Oceanographic Services in Canada – How to get help from the Government*** *(Harinder Ahluwalia)*		
	12:00-13:30	**LUNCH**	**12:00-13:30**	**LUNCH**
C/D Ballrooms	**13:30-15:00**	**3-C-1: *NSERC / CFCAS Information Sessions*** *(Geoff Strong)*		
5–Piesporter	**13:30-15:00**		**13:30-15:00**	**4-C-1: *Atmospheric Modelling III – Climate & Data Assimilation*** *(Stéphane Laroche)*
7–Medeira	**13:30-15:00**		**13:30-15:00**	**4-C-2: *Geophysical Fluid Dynamics II*** *(Bruce Sutherland)*
9–Bordeaux	**13:30-15:00**		**13:30-15:00**	**4-C-3: *Hazardous Weather VII – Hurricane Juan*** *(Geoff Strong)*
10–Beaujolais	**13:30-15:00**		**13:30-15:00**	**4-C-4: *Aviation Meteorology IV – Science Transfer & Training*** *(Steve Knott)*
12–Chablis	**13:30-15:00**	**3-C-6: *Building Meteorological & Oceanographic Services in Canada – An Update*** *(Barry Green/Susan Woodbury)*	**13:30-15:00**	**4-C-5: *Atmospheric Boundary Layer & Air Quality*** *(Peter Taylor)*
	15:00-15:30	**HEALTH BREAK**		
C/D Ballrooms	**15:30-17:00**			
5–Piesporter	**15:30-17:00**	**3-D-1: *Canadian Community Model I*** *(Gilbert Brunet)*		
7–Medeira	**15:30-17:00**	**3-D-2: *Northern Oceans III*** *(Paul Myers)*		
9–Bordeaux	**15:30-17:00**	**3-D-3: *Prairie Drought/Water Issues II – joint CMOS/CGU Session*** *(Barrie Bonsal)*		
10–Beaujolais	**15:30-17:00**	**3-D-4: *Mountain Meteorology*** *(Henry Stanski)*		
12–Chablis	**15:30-17:00**	**3-D-5: *CFCAS Report to Canadians on Climate Science – cont'd*** *(Gordon McBean)*		
A/B Ballrooms	**15:30-17:00**			
C/D Ballrooms	**18:00-21:00**	***COCKTAILS and BANQUET***		

Time	C/D Ballrooms	5–Piesporter	7–Medeira
08:30-09:00	**Welcome & Introductions**		
09:00-10:30	**1-A** **Plenary** *(Geoff Strong)*		
09:00	**1-A.1** Struck by Lightning: A Lifelong Sentence. ***Mary Ann Cooper***		
09:45	**1-A.2** Climate Change: How it Will Affect Natural Hazards. ***Gordon A McBean***		
10:30-11:00	**HEALTH BREAK**		
11:00-12:30	**1-B-1** **Health Issues in** **Weather and Climate I** *(Denis Bourque)*	**1-B-2** **Climate Change I –** **Modelling and Paleoclimate** *(Andy Bush)*	**1-B-3** **Air-Sea Interactions and Waves I** *(Bridget Thomas)*
11:00	**1-B-1.1** Is Hot and/or Dry Weather Associated with the Spreading of West Nile Virus in Canada? ***Marjolijn van der Hoek***	**1-B-2.1** Sea-Ice Representation in Global Climate Models. ***Gregory M Flato***	**1-B-3.1** Shoaling Waves Experiment – Air-Sea Interaction in a Coastal Region. ***Robert J Anderson***
11:15	**1-B-1.2** The Potential Role of High Impact Weather Events in Waterborne Disease Outbreaks in Canada, 1975-2001. ***James E Valcour***	**1-B-2.2** Simulation of Sulphate Size Distributions in the CCCma GCM. ***Xiaoyan Ma***	**1-B-3.2** On the Air-Sea Coupling Coefficients for Momentum, Heat and Mass in High Winds. ***Mark A Donelan***
11:30	**1-B-1.3** Impact of Climate and Agriculture on Enteric Illness in Atlantic Canada: Toward a Climate Change Adaptation Strategy. ***James E Valcour***	**1-B-2.3** Global Circulation of Mercury in a Numerical Weather Model. ***Ashu P Dastoor***	**1-B-3.3** Tsunami Heights and Currents from a Cascadia Megathrust Earthquake. ***Josef Cherniawsky***
11:45	**1-B-1.4** Seasonal Trends in Temperature and Foodborne Illness. ***Manon D Fleury***	**1-B-2.4** The Greening of the McGill Paleoclimate Model, Part I: Improved Land Surface Scheme with Vegetation Dynamics. ***Yi Wang***	**1-B-3.4** Nearshore Wave Attenuation during Hurricane Juan. ***Peter C Smith***
12:00	**1-B-1.5** Climate Warming and Emerging Infectious Diseases in Arctic and Sub-Arctic Wildlife. ***Susan J Kutz***	**1-B-2.5** Large-Scale Ice Discharge Events in a Pure Ice Sheet Model. ***Brian Papa***	**1-B-3.5** Blending Parametric Hurricane Surface Fields into CMC Forecasts and Evaluating Impact on Storm Surge for Hurricane Juan. ***Serge Desjardins***
12:15		**1-B-2.6** Simulation of the Last and Next Glacial Inceptions with the Green McGill Paleoclimate Model. ***Anne S Cochelin***	**1-B-3.6** Evacuation in White Bay, Newfoundland during the Winter Storms of 1989 and 2004. ***Bruce L Whiffen***
12:30-14:00	**LUNCH**		

9–Bordeaux	10–Beaujolais	12–Chablis	Time
			08:30-09:00
			09:00-10:30
			09:00
			09:45
HEALTH BREAK			**10:30-11:00**
1-B-4 **Aviation Meteorology I –** **Verification and Data** *(Steve Ricketts)*	**1-B-5** **Hazardous Weather I –** **Severe Convective Processes** *(Dave Sills)*		**11:00-12:30**
1-B-4.1 NAV Canada and Meteorological Service of Canada: Aviation Performance Measurements, Trend Analysis and the Future. ***Henry Stanski***	**1-B-5.1** ELBOW 2001: Analysis of Low-Level Boundaries in Southwestern Ontario. ***Lisa S Alexander***		11:00
1-B-4.2 Trends on the Usage of Groups (TEMPO, FM) in Aviation Aerodrome Forecasts (TAFs). ***Craig MacLaren***	**1-B-5.2** Regional Evapotranspiration and Moist Deep Convection on the Canadian Prairies. ***Richard L Raddatz***		11:15
1-B-4.3 Wind Profiler in Airport Environment. ***Philipp Currier***	**1-B-5.3** The Dryline as a Mechanism for Severe Thunderstorm Initiation on the Canadian Prairies. ***Neil M Taylor***		11:30
1-B-4.4 Progress on the Development of the Canadian Aircraft Meteorological Data Relay (AMDAR) Program. ***Gilles Fournier***	**1-B-5.4** The Pre-Storm Capping Lid and Dryline during A-GAME 2003. ***GS Strong***		11:45
1-B-4.5 Flight Test Results from a New AMDAR System. ***Graham Bruce***	**1-B-5.5** Local Initiation of Deep Convection on the Canadian Prairies. ***John Hanesiak***		12:00
	1-B-5.6 HAILCAST as an Operational Forecast Tool – Performance for Three Severe Hail Events over the Canadian Prairies. ***Julian C Brimelow***		12:15
LUNCH			**12:30-14:00**

Time	C/D Ballrooms	5–Piesporter	7–Medeira
14:00-15:30	**1-C-1 Health Issues in Weather and Climate II** *(Denis Bourque)*	**1-C-2 Sea-Level Rise Impacts** *(Hal Ritchie)*	**1-C-3 Climate Change II – Data and Quality Control** *(Steve Lambert)*
14:00	**1-C-1.1** Predicting the Risk of Freezing due to Wind Chill. ***Peter Tikuisis***	**1-C-2.1** Impacts of Sea Level Rise and Climate Change on the Coastal Zone of Southeastern New Brunswick. ***Réal Daigle*** **(Invited)**	**1-C-3.1** Atmospheric Monitoring Network Data Quality Assurance Requirements and Approaches. ***Richard Campbell***
14:15	**1-C-1.2** Renewed UV Index Program in Canada. ***Angus Fergusson***		**1-C-3.2** Calculation of the 1971 to 2000 Climate Normals for Canada. ***Debra J Allsopp***
14:30	**1-C-1.3** Potential Climatic Indicators for Water Contamination and Consequent Drinking Water Disease Outbreaks. ***Corinne J Schuster***	**1-C-2.2** Hindcast of Storm Surges in the Northwest Atlantic, 1960-1999. ***Natacha B Bernier***	**1-C-3.3** Access to Historical Weather and Climate Data from the MSC. ***Robert J Morris***
14:45	**1-C-1.4** Atlantic Region Meteorological Health Strategy. ***Kenneth Kirkwood***	**1-C-2.3** Analysis of Historical Water Level Variations, Storm Surges and Return Periods for the Estuary and Gulf of St. Lawrence. ***Zhigang Xu***	**1-C-3.4** Modernization of the National Climate Hardcopy Archives in Downsview (CHAD). ***Anna Deptuch-Stapf***
15:00	**1-C-1.5** Weather and Death on Mount Everest: An Analysis of High Impact Storms at Extreme Altitude. ***John Semple***	**1-C-2.4** Climate Change Impacts on Beaufort Sea Shoreline. ***Gavin K Manson***	**1-C-3.5** COOLTAP – Real-Time Distribution of MSC T&P Climate Data. ***John MacPhee***
15:15		**1-C-2.5** Historical and Possible Future Changes of Wave Heights in Northern Hemisphere Oceans. ***Xiaolan L Wang***	
15:30-16:00	**HEALTH BREAK**		
16:00-17:30	**1-D-1 Societal Implications of Weather and Climate** *(Denis Bourque)*	**1-D-2 Basin to Global Ocean Data Assimilation I** *(Keith Thompson)*	**1-D-3 High Latitude Processes** *(Dan Kulak)*
16:00	**1-D-1.1** Arctic Catastrophes: Rapid Sea Ice Changes in the Canadian Arctic and the Impact on Humans. ***Peta J Mudie***	**1-D-2.1** Course and Fine Resolution Modelling of the North Atlantic Thermohaline Circulation. ***Carsten Eden*** **(Invited)**	**1-D-3.1** Forecasting Polar Lows in the Norwegian and Barents Sea. ***Gunnar Noer*** **(Invited)**
16:15	**1-D-1.2** Linking Climate Variability and Community Outcomes through Historical Newspaper Analysis of Extreme Weather and Disaster Events. ***Karen McDonald***		
16:30	**1-D-1.3** The Road Well Travelled: Implications of a Future Climate on the Performance of Pavement Infrastructure in Southern Canada. ***Brian Mills***	**1-D-2.2** Project Argo – Current Status and Expectations. ***Howard J Freeland*** **(Invited)**	**1-D-3.2** Polar Lows: An International Collaboration to Enhance Northern Latitude Forecasting. ***Bruce Muller***
16:45	**1-D-1.4** Science for Ontario Municipalities' Emergency Management Planning: the Atmospheric Hazards in Ontario Website. ***Joan Klaassen***		**1-D-3.3** Climatological Characteristics of Northern Hemisphere Winter Anticyclones. ***Lily Ioannidou***
17:00	**1-D-1.5** Collisions, Causalities, and Costs: Weathering the Elements on Canadian Roads. ***Brian Mills***	**1-D-2.3** Quantifying Measurement Errors in ERS and ENVISAT Satellite Altimetry. ***Graig J Sutherland***	**1-D-3.4** Forecast Support to the Canadian Arctic Through-Flow Study, an Oceanographic Expedition to Nares Strait on the U.S. Icebreaker Healy, Summer 2003. ***Edward Hudson***
17:15		**1-D-2.4** Coupled regional climate simulation in the Gulf of St. Lawrence, Eastern Canada. ***Manon Faucher***	**1-D-3.5** Wind Forecast Investigation Tool (WFIT) – Application and Preliminary Results for Arctic Sites. ***Anke Kelker***
17:30-18:30			
17:30-19:00	**1-P-1 Poster Session** *(Claude Labine)* **(**Ballrooms A/B**)**		
18:00-19:30	**Ice Breaker**		

9–Bordeaux	10–Beaujolais	12–Chablis	Time
1-C-4 **Aviation Meteorology II – Icing** *(Stewart Cober)*	**1-C-5** **Hazardous Weather II** **Severe Convection Case Studies** *(Geoff Strong)*		**14:00-15:30**
1-C-4.1 A High Resolution Full-Scale 3D Model of Glaze Ice Accretion on a Non-Energized Station Post Insulator. ***Wladyslaw J Rudzinski***	**1-C-5.1** The Tornadoes in Ontario Project (TOP). ***David ML Sills***		14:00
1-C-4.2 A Portable Calorimeter for Measuring Liquid Fraction in Spongy Freshwater Ice Accretion. ***Ryan Z Blackmore***	**1-C-5.2** A Case Study of Three Severe Tornadic Storms in Alberta. ***Max Dupilka***		14:15
1-C-4.3 Systematic Experiments on Ice Spike Growth in a Cold Room. ***Edward P Lozowski***	**1-C-5.3** The Edmonton Severe Thunderstorm of 7 August 2003. ***B Kochtubajda***		14:30
1-C-4.4 Detection of In-Flight Icing Conditions through the Analysis of Hydrometeors with a Vertically Pointing Radar. ***Jennifer Lilly***	**1-C-5.4** Severe Weather Outbreak South-Central Alberta on 11 August 2003. ***Lesley Hill***		14:45
1-C-4.5 Aircraft Icing Environments in Mixed Phase Clouds. ***Stewart G Cober***	**1-C-5.5** Exploratory Analysis of the Effect of Hail Suppression Operations on Precipitation in Alberta. ***Terrence W Krauss***		15:00
	1-C-5.6 The Alberta Hail Suppression Program: A Program Designed to Mitigate Urban Hail Damage in the Province of Alberta, Canada. ***James Renick***		15:15
HEALTH BREAK			**15:30-16:00**
1-D-4 **Prairie Drought/Water Issues I** **– joint CMOS/CGU Session** *(Ron Stewart)*	**1-D-5** **Hazardous Weather III** **– Lightning and WildFires** *(Bill Burrows)*		**16:00-17:30**
1-D-4.1 An Examination of the Major Spatial Patterns of Growing-Season Agricultural Drought in the Canadian Prairies. ***Steven M Quiring***	**1-D-5.1** Winter Lightning Climatologies – the Reality. ***Peter J Lewis***		16:00
1-D-4.2 On the Genesis of Prolonged Droughts in Canada. ***Amir Shabbar***	**1-D-5.2** Convective Precipitation and Cloud to Ground Lightning Relationships in Canada. ***B Kochtubajda***		16:15
1-D-4.3 Atmospheric Circulation Patterns Associated with the 2001 and 2002 Canadian Droughts. ***Barrie R Bonsal***	**1-D-5.3** 1 to 2 Day Prediction of the Probability of Lightning Occurrence over Canada and the Northern United States in the Warm Season. ***William R Burrows***		16:30
1-D-4.4 Small Scale Characteristics of Canadian Prairie Drought. ***Erin Roberts***	**1-D-5.4** Verification of a Lightning Forecast Model during A-GAME. ***B Kochtubajda***		16:45
	1-D-5.5 A Severe Winter Lightning Storm over Nova Scotia and Adjacent Waters – January 2000. ***Peter J Lewis***		17:00
	1-D-5.6 The Canadian Wildland Fire Information System. ***Kerry R. Anderson***		17:15
		UNSTABLE (Unified Severe Thunderstorm Atmospheric Boundary Layer Experiment) **Meeting** *(GS Strong)*	**17:30-18:30**
			17:30-19:00
			18:00-19:30

Time	C/D Ballrooms	5–Piesporter	7–Medeira
08:30-08:35	**Announcements**		
08:35-10:05	**2-A** **Plenary** *(Paul Myers)*		
08:35	**2-A.1** Remote-Sensing and New Technologies: a New Era. ***Virendra Jha***		
09:20	**2-A.2** Ocean Modelling using Mixed Spectral/Finite Element/Finite Volume Methods. ***DB Haidvogel***		
10:05-11:00	**HEALTH BREAK**		
10:30-12:00		**2-B-1** **Future Role of Operational Meteorology** *(Jim Abraham)*	**2-B-2** **Remote Sensing I – Satellite** *(Enrico Torlaschi)*
10:30		**2-B-1.1** Creating an Aviation Centre of Excellence. ***Steve Ricketts*** **(Invited)**	**2-B-2.1** Canada and the Global Precipitation Measurement Mission. ***Paul Joe*** **(Invited)**
10:45			
11:00		**2-B-1.2** Discarding the Forecast Funnel. ***Kent A Johnson***	**2-B-2.2** Detection and Monitoring of Precipitation from Space: Winter Case Studies. ***Irene G Rubinstein***
11:15		**2-B-1.3** Verification of Public and Commercial Temperature Forecasts. ***Patrick J McCarthy***	**2-B-2.3** Sea-Ice Motion Estimation using the Advanced Microwave Scanning Radiometer for EOS (AMSR_E). ***Tom Agnew***
11:30		**2-B-1.4** A Fuzzy Logic-based Analog Forecasting System for Ceiling and Visibility. ***Bjarne Hansen***	**2-B-2.4** Regional Validation of Passive Microwave Satellite Derived Snow Water Equivalent in Canada. ***Chris Derksen***
11:45			**2-B-2.5** Satellite Winds Assimilation with CMC Operational NWP System. ***Réal Sarrazin***
12:00-14:00	**CMOS AWARDS LUNCHEON**		

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listed by **Presenter** only

Day 2, Tuesday 01 June – *Session Schedule*
2ième jour, Mardi 01 juin – *Horaire des presentations*

9–Bordeaux	10–Beaujolais	12–Chablis	Time
			08:30-08:35
			08:35-10:05
			08:35
			09:20
	HEALTH BREAK		**10:05-11:00**
2-B-3 **Basin to Global Ocean Data Assimilation – II** *(Keith Thompson)*	**2-B-4** **MAGS Special Session – Toward a Deeper Understanding of the Regional Climate of Northwest Canada I** *(Hok Woo)*	**2-B-5** **Cloud Physics** *(Ed Lozowski)*	**10:30-12:00**
2-B-3.1 Modelling Long-Term Hydrography Changes in the North Atlantic. ***Daniel G Wright***	**2-B-4.1** Climate Variability in the Mackenzie Basin: Observations, Theory and Modelling. ***Kit Szeto* (Invited)**	**2-B-5.1** Effects of Turbulence on Cloud Droplet Collision Rates. ***Charmaine N Franklin***	10:30
2-B-3.2 Towards an Operational Analysis and Forecast System for the North Atlantic Ocean: Initial Implementation and Forecast Skill Assessment. ***Keith R Thompson***		**2-B-5.2** A Microphysics Parameterization Scheme for Radar Data Assimilation. ***Stéphane Laroche***	10:45
2-B-3.3 Simulation of the Northeast Pacific using Various Nudging Schemes. ***Michael W Stacey***	**2-B-4.2** The Pacific North American Pattern – an Overview. ***Jacques Derome* (Invited)**	**2-B-5.3** Numerical Simulation of a Hailstorm using a Triple-Moment Bulk Microphysics Scheme in a Mesoscale Model. ***Jason A Milbrandt***	11:00
2-B-3.4 Design of Data Assimilation System for North Pacific Ocean Circulation. ***Tsuyoshi Wakamatsu***		**2-B-5.4** High-Resolution Numerical Simulation of Convective Roll Clouds Associated with High Latitude Cold Air Outbreaks. ***Anthony Q Liu***	11:15
2-B-3.5 Storm-Induced Circulation on the Scotian Shelf and Slope using Two-Way Nested-Grid Ocean Circulation Modelling System. ***Jinyu Sheng***	**2-B-4.3** Association of an Upstream Blocking Regime upon Mackenzie River Basin Temperature and Precipitation Structures during the Boreal Cold Season. ***John R Gyakum***	**2-B-5.5** Winter Precipitation Formation and its Impact on Visibility. ***Julie Theriault***	11:30
2-B-3.6 Strategy for the Development of an Operational Canadian Global Assimilation and Prediction Capability for the Coupled Atmosphere-Ocean-Ice System. ***Hal Ritchie***	**2-B-4.4** Evidence of Association of the AO/NAO with the SST Anomaly in the Tropical Pacific. ***Hai Lin***		11:45
			12:00-14:00

Time	C/D Ballrooms	5–Piesporter	7–Medeira
14:00-15:30		**2-C-1 Aviation Meteorology III – Forecast Techniques** *(Steve Ricketts)*	**2-C-2 Remote Sensing II – Radar** *(Paul Joe)*
14:00		**2-C-1.1** An Update on "TAFtime /Thermobot": Experience in Forecast Operations. ***Steven Laroche***	**2-C-2.1** Three Dimensional Intercomparison of Canadian Weather Radars. ***Norman R Donaldson***
14:15		**2-C-1.2** Application of a Radiation Fog Technique to Canadian Aviation Weather Forecasts. ***Mervyn Jamieson***	**2-C-2.2** The Effect of the Degree of Common Orientation of the Hydrometeors on Polarimetric Radar Observables. ***Enrico Torlaschi***
14:30		**2-C-1.3** Nowcasting Airport Winter Weather: First Results from AIRS 2. ***George A Isaac***	**2-C-2.3** A Comparison of the Radar Decision Support System and Unified Radar Processor in the Analysis of Two Severe Weather Events on the Prairies. ***Derrick Kania***
14:45		**2-C-1.4** Heads up TAF Alerting – A First Step. ***Erik de Groot***	**2-C-2.4** The Implement of the Background Error Covariance in the Cloud-Scale Radar Data Assimilation Cycles. ***Chia-Hui Chiang***
15:00			**2-C-2.5** Description of the Canadian Precipitation Analysis (CaPA) Project. ***Stéphane Gagnon***
15:15			**2-C-2.6** The BC Wildfires of 2003: Tracers for Detection of Atmospheric Features by Weather Radar and Satellites. ***Robert Nissen***
15:30-16:00	**HEALTH BREAK**		
16:00-17:30	**2-D-1 Atmospheric Monitoring – Emerging Technologies** *(Bob Kochtubajda)*	**2-D-2 Hazardous Weather IV – Winter Storms** *(Peter Bowyer)*	**2-D-3 Micro-Meteorology** *(Claude Labine)*
16:00	**2-D-1.1** Proposed Research Applications for "POSS". ***Brian E Sheppard***	**2-D-2.1** The Maritime Blizzard of 2004. ***Carolyne Marshall***	**2-D-3.1** Farm Emissions Estimates using an Inverse Dispersion Technique. ***Thomas K Flesch***
16:15	**2-D-1.2** Ground-Based Radiometric Profiling during Dynamic Weather Conditions. ***Randolph H Ware***	**2-D-2.2** Severe Ice Storm Risks in Ontario. ***Joan Klaassen***	**2-D-3.2** Winds around a Thick Hedge. ***John D Wilson***
16:30	**2-D-1.3** Initial Investigation on the Use of Ram Falls SODAR Data for Assessing the Potential for Summer Convection in Alberta. ***Robert Peirson***	**2-D-2.3** Lake-Effect Snowstorms over Southern Ontario and their Associated Synoptic-Scale Environment. ***Anthony Q Liu***	**2-D-3.3** On the Relevance of a Diffusive Treatment for Heavy Particle Dispersion. ***Thomas Bouvet***
16:45	**2-D-1.4** Preliminary Results from a Performance Evaluation of Temperature and Humidity Sensors in the Canadian Climate Network. ***Tomasz Stapf***	**2-D-2.4** A Classification Scheme for High Impact Winter Weather on the Canadian Prairies. ***Jim Slipec***	**2-D-3.4** Dispersion Modelling of Xe-133 in the Ottawa River Valley. ***Réal D'Amours***
17:00		**2-D-2.5** The Roles of Blocking, Thermal Advection, Melting, and the Associated Thermodynamic Structure in Generating the Snowfall Distribution of the Great Western Storm. ***Douglas A Wesley***	
17:15		**2-D-2.6** Arctic Winter Weather and Forecasting – Experience Helps. ***Paul Yang***	
17:30-18:30			
19:30-21:30	**CMOS Annual General Meeting**		

9–Bordeaux	10–Beaujolais	12–Chablis	Time
2-C-3 **Regional Ocean Modelling** *(Kim Schmidt)*	**2-C-4** **MAGS Special Session** **– Toward a Deeper Understanding of the Regional Climate of Northwest Canada II** *(John Gyakum)*	**2-C-5** **Statistical Climatology I** *(Sam Shen)*	**14:00-15:30**
2-C-3.1 An Analysis of Freshwater Transport in an Eddy-Permitting Regional Model of the Sub-Polar North Atlantic. ***Paul G Myers***	**2-C-4.1** Development of Canadian Regional Climate Model v.4. ***Laxmi Sushama*** **(Invited)**	**2-C-5.1** A Drought Reporting System for Agriculture in Alberta. ***Allan E Howard*** **(Invited)**	14:00
2-C-3.2 A Regional Eddy-Permitting Ocean Model of the Sub-Polar North Atlantic under Flux Forcing. ***Duo Yang***			14:15
2-C-3.3 Sensitivity of an Eddy-Permitting Ocean Model to Different Parameterizations for Tracer Mixing. ***Daniel Deacu***	**2-C-4.2** Comparison of Simulation by two Regional Atmospheric Models over the Mackenzie River Basin. ***Iriola Mati***	**2-C-5.2** Observed Changes of Cyclone Activities in Canada. ***Hui Wan***	14:30
2-C-3.4 Seasonal Circulation variability over the Newfoundland Shelf and Slope. ***Guoqi Han***	**2-C-4.3** MC2 Simulations of the Interaction of Airflow with the Western Cordillera during Extreme Winter Temperature Events over the Mackenzie River Basin. ***Kit Szeto***	**2-C-5.3** Assessment of Observational Biases and Trends in Canadian Cloudiness. ***Xiaolan L Wang***	14:45
2-C-3.5 Toward a Regional Operational Model for the Newfoundland Shelf. ***Fraser JM Davidson***	**2-C-4.4** Teleconnections, 1000-500 hPa Thickness and Storm Tracks in the Northern Hemisphere. ***Eyad Atallah***	**2-C-5.4** Temporal and Spatial Changes of the Agroclimate in Alberta from 1901-2002. ***Huamei Yin***	15:00
2-C-3.6 Resolution Issues in Numerical Circulation Models. ***David A Greenberg***	**2-C-4.5** Variability of the Bulk Heat Exchange of Great Slave Lake. ***William M Schertzer***	**2-C-5.5** Calibration of Dynamical Seasonal Prediction with Ensemble Principal Component Regression. ***Ruping Mo***	15:15
HEALTH BREAK			**15:30-16:00**
2-D-4 **Northern Oceans I** *(Paul Myers)*	***MAGS*** **closed working group** *(Hok Woo)*		**16:00-17:30**
2-D-4.1 Argo as an Aid to Environmental Monitoring and Assessment – the Example of the Gulf of Alaska. ***Howard J Freeland***			16:00
2-D-4.2 An Examination of Mixed Layer Depth along Line P and in the Gulf of Alaska. ***Michelle Li***			16:15
2-D-4.3 Dimethyl Sulfide in Eastern Sub-Arctic Pacific: Flux Change during 1997-98 El Niño. ***CS Wong***			16:30
2-D-4.4 Wind-Driven Inter-Annual Variability over the Northeast Pacific Ocean. ***Patrick F Cummins***			16:45
2-D-4.5 Revisiting the Juan de Fuca Eddy: Modeling and Observational Studies. ***Mike Foreman***			17:00
2-D-4.6 Parameterization of Subsurface Temperatures in the Lamont Ocean Model using Neural Networks. ***Shuyong Li***			17:15
		Closed Meeting	**17:30-18:30**
			19:30-21:30

Time	**C/D Ballrooms**	**5–Piesporter**	**7–Medeira**
08:30-08:35	**Announcements**		
08:35-10:05	**3-A** **Plenary** *(Marc Denis Everell)* Assistant Deputy Minister, MSC		
08:35	**3-A.1** Stewardship of our Earth Resources through a Comprehensive, Coordinated and Sustained Global Observation System. ***Vice-Admiral Conrad C Lautenbacher, Jr, US Navy (Ret.)***		
09:20	**3-A.2** Canada's Northern Oceans: Connectivity, Mechanics and Human Ties. ***Eddy Carmack***		
10:05-10:30	**HEALTH BREAK**		
10:30-12:00	**3-B-1** **Climate Change III – Telecommunications** *(K Andrew Peterson)*	**3-B-2** **Hazardous Weather V – Emerging Forecasting Methodologies** *(Neil Taylor)*	**3-B-3** **Northern Oceans II** *(Howard Freeland)*
10:30	**3-B-1.1** The Role of the Western Pacific in Decadal Variability. ***Bin Yu***	**3-B-2.1** Current Status and Future Improvements in the Canadian Meteorological Centre's Operational Forecasting Suite. ***Richard Hogue***	**3-B-3.1** Observation and Modelling of Hydrothermal Vent-Induced Circulation at the Endeavour Segment of Juan de Fuca Ridge. ***Richard E Thomson* (Invited)**
10:45	**3-B-1.2** The Nonlinear Patterns of North American Winter Temperature and precipitation Associated with ENSO. ***Aiming Wu***	**3-B-2.2** Scribe Nowcasting Sub-System – Version 1.0: First Objective Verification Results. ***Claude Landry***	
11:00	**3-B-1.3** Changing Influence of ENSO on Euro-Atlantic Winter Climate. ***K. Andrew Peterson***	**3-B-2.3** Nowcasting based on Surface Observations. ***Pierre Bourgouin***	**3-B-3.2** Insights into Sea Ice Thickness Distributions Derived from Ice Geometry. ***Trisha L Amundrud***
11:15	**3-B-1.4** The Influence of Tropical Forcing on the Arctic Oscillation. ***XiaoJing Jia***	**3-B-2.4** Research and Private Sector Applications of the Aurora and FPA Graphical Database System. ***Brian Greaves***	**3-B-3.3** International Arctic Buoy Programme (IABP) – Applications of Buoys on Ice in the Arctic Basin. ***Edward Hudson***
11:30	**3-B-1.5** Wavelet Analysis on Variability, Teleconnectivity and Predictability of East African Rainfall. ***Davison Mwale***	**3-B-2.5 A**n Extreme Forecast Index for the Canadian Ensemble Prediction System – Slicing through all that Spaghetti. ***Syd Peel***	**3-B-3.4** On the Formation and Circulation of the Intermediate Waters of the Gulf of St Lawrence. ***Gregory C Smith***
11:45	**3-B-1.6** On the Reliability of Climate Dynamical Predictions. ***Youmin Tang***	**3-B-2.6** Ensemble Prediction – the Sixth Dimension. ***Kent A Johnson***	
12:00-13:30	**LUNCH**		

9–Bordeaux	10–Beaujolais	12–Chablis	Time
			08:30-08:35
			08:35-10:05
			08:35
			09:20
HEALTH BREAK			**10:05-10:30**
3-B-4 **Remote Sensing IV** **GPS Measurement and Modelling of Atmospheric Moisture** *(Susan Skone)*	**3-B-5** **MAGS Special Session – Toward a Deeper Understanding of the Regional Climate of Northwest Canada III** *(Kit Szeto)*	**3-B-6** **Building Meteorological and Oceanographic Services in Canada – How to get help from the Government** *(Harinder Ahluwalia)*	**10:30-12:00**
3-B-4.1 Ground-Based Radiometric Profiling during Dynamic Weather Conditions. ***Randolph H Ware*** **(Invited)**	**3-B-5.1** Atmospheric Circulation Patterns of Extreme Lightning Events and Associated Wildfires in the Mackenzie Basin. ***Andrew M Way***	**3-B-6.1** Canadian Commercial Corporation. ***Bruce Fox*** **(Invited)**	10:30
3-B-4.2 GPS Data, Products and Services for Meteorology. ***Pierre Héroux***	**3-B-5.2** Quantitative Precipitation Forecast Verification in the Edmonton Area. ***Olivier Bousquet***		10:45
3-B-4.3 Evaluation of GPS Precipitable Water over Canada and the Global IGS Network. ***Stephen Macpherson***	**3-B-5.3** Modelling of Wind Climate in Yukon Mountainous Terrain. ***JD Jean-Paul Pinard***	**3-B-6.2** Industrial Research Assistance Program (NRC-IRAP). ***Cal Koskowich*** **(Invited)**	11:00
3-B-4.4 Estimates of Atmospheric Moisture in a Regional GPS Network. ***Victoria A Hoyle***	**3-B-5.4** Permafrost-Climate Variations in the Mackenzie Mountains, NWT, Canada. ***G Peter Kershaw***		11:15
3-B-4.5 Comparing GPS and Radiosonde Derived Atmospheric Moisture during A-GAME 2003. ***Craig D Smith***	**3-B-5.5** Hydrologic Modelling of Athabasca River Basin by Meteorological, Land Surface and Hydrologic Models, and *a priori* Land Surface Data. ***Thian Yew Gan***	**3-B-6.3** Canadian International Development Agency (CIDA). ***Ruth Shapiro*** **(Invited)**	11:30
3-B-4.6 Wet Refractivity Modelling in a Regional GPS Network. ***Natalya A Nicholson***	**3-B-5.6** Producing the Drainage Layer Database for North America. ***Frank R Seglenieks***		11:45
LUNCH			**12:00-13:30**

Time	C/D Ballrooms	5–Piesporter	7–Medeira
13:30-15:00	**3-C-1** **NSERC / CFAS** **Information Session** *(Geoff Strong)*		
13:30	**3-C-1.1** NSERC Information ***Dennis Blinn***		
13:45			
14:00			
14:15	**3-C-1.2** CFCAS Report to Canadians on Climate Science ***Gordon A McBean***		
14:30			
14:45			
15:00-15:30	**HEALTH BREAK**		
15:30-17:00		**3-D-1** **Canadian Community Model I** *(Gilbert Brunet)*	**3-D-2** **Northern Oceans III** *(Paul Myers)*
15:30		**3-D-1.1** An Unstable Semi-Implicit Scheme made Stable. ***Michel Desgagné***	**3-D-2.1** The Variability of the Labrador Current off Hamilton Bank. ***R Allyn Clarke***
15:45		**3-D-1.2** Large Atmospheric Computation on the Earth Simulator (LACES) with the Canadian MC2 Model – a Status Report. ***Michel Desgagné***	**3-D-2.2** Current Structure and Variability in Flemish Pass in 2002-03. ***John W Loder***
16:00		**3-D-1.3** MC2 Simulation of the Effect of Cloud Processes on Post-Cloud Aerosol. ***Irena T Paunova***	**3-D-2.3** Water Mass Transport Rates in the North Atlantic with a Special Focus on the Labrador Sea. ***Nilgun Cetin***
16:15		**3-D-1-4** Numerical Simulation of the 17-18 July 1996 Chicago Flood. ***Xingbao Wang***	**3-D-2.4** An Isopycnal View of Oxygen in the Northwest Atlantic. ***Denis Gilbert***
16:30		**3-D-1.5** An Assessment of MC2 Precipitation Simulation during the Intensified Observation Period of the HUBEX/GAME Project in China. ***Lei Wen***	**3-D-2.5** Surface Currents on the Grand Banks. ***Charles Tang***
16:45		**3-D-1.6** The New Regional GEM 15 km Model. ***Louis Lefaivre***	
18:00-18:30	**Cocktails**		
18:30-21:00	**Banquet**		

9–Bordeaux	10–Beaujolais	12–Chablis	Time
		3-C-6 **Building Meteorological and Oceanographic Services in Canada – An Update** *(Barry Green/Susan Woodbury)*	**13:30-15:00**
		3-C-6.1 MSC Technical and Service Direction Update. ***Philip Jacobson* (Invited)**	13:30
			13:45
		3-C-6.2 Meteorologists and the Environment Sector. ***Grant S Trump* (**Invited)	14:00
			14:15
		3-C-6.3 Private Sector Initiatives. ***Susan K Woodbury* (Invited)**	14:30
			14:45
HEALTH BREAK			**15:00-15:30**
3-D-3 **Prairie Drought/Water Issues II – joint CMOS/CGU Session** *(Barrie Bonsal)*	**3-D-4** **Mountain Meteorology** *(Henry Stanski)*	**3-D-5** **CFCAS Report to Canadians on Climate Science – cont'd** *(Gordon McBean)*	**15:30-17:00**
3-D-3.1 Drought Risk Assessment on the Canadian Prairies. ***Aston C Chipanshi***	**3-D-4.1** The Relationship between Elevation and Monthly Precipitation Accumulations in the Alberta Foothills. ***Craig D Smith***		15:30
3-D-3.2 Winter Season Snow Water Equivalent Variability across Western Canada (1978-2002) Inferred from Spaceborne Passive Microwave Data. ***Chris Derksen***	**3-D-4.2** Effects of Topographic Slopes on Hydrological Processes in the Penn State NCAR MM5-LSM Modeling System. ***Yi-Nan Ku***		15:45
3-D-3.3 Climate Impact on Net Ecosystem Productivity of a Semi-Arid Natural Grassland – Modelling and Measurement. ***Tao Li***	**3-D-4.3** Orographic Effects and Sandstorms Observed in East Asia. ***Yong S Chung***		16:00
3-D-3.4 Daily Evapotranspiration Trends and Drought Monitoring using GPS Moisture. ***GS Strong***	**3-D-4.4** Upstream Orographic Blocking on the Mediterranean Side of the Alps – a MAP Case Study. ***Olivier Bousquet***		16:15
3-D-3.5 A Study of Climate Change, Water Availability, and Regional Socio-Economic Impacts in the South Saskatchewan River Basin. ***Lawrence Martz***	**3-D-4.5** Weather and Mountain Waves Forecast over Central and Southern Andes. ***Alessia Borroni***		16:30
3-D-3.6 Global and Regional Atmospheric Water Balances. ***Bruce R Peachey***			16:45
			18:00-18:30
			18:30-21:00

Time	C/D Ballrooms	5–Piesporter	7–Medeira
08:30-08:35	**Announcements**		
08:35-10:05	**4-A** **Plenary** *(Steve Ricketts))*		
08:35	**4-A.1** Hurricanes in Canada: the Threat, the Impacts, Forecast and Research Challenges. ***Jim Abraham***		
09:20	**4-A.2** Micrometeorology and Carbon Balance Research in Northern Forests. ***T Andrew Black***		
10:05-10:30	**HEALTH BREAK**		
10:30-12:00	**4-B-1** **Climate Change IV** *(Phil Merilees)*	**4-B-2** **Canadian Community Model II** *(Louis Lefaivre)*	**4-B-3** **Geophysical Fluid Dynamics** *(Bruce Sutherland)*
10:30	**4-B-1.1** Past and Future Fire Weather: What is the Climate Change Outlook? ***Brian Amiro***	**4-B-2.1** Application and Evaluation of MC2 in Regional Air Quality Studies. ***Mike Lepage***	**4-B-3.1** Double Diffusive Mixing in Shear-Driven Overturns. ***William D Smyth*** **(Invited)**
10:45	**4-B-1.2** Estimating extremes in Transient Climate Change Simulations. ***Viatcheslav V Kharin***	**4-B-2.2** Using the MC2AQ Model to Study the Transport and the Back Trajectories of the Stable Carbon Isotope Ratios in the Oxidation of Hydrocarbons. ***Farida Dehghan***	
11:00	**4-B-1.3** Monitoring Air Quality and Climate Change Occurring over East Asia. ***Yong S Chung***	**4-B-2.3** MC2 Simulations of Recirculation Processes in the Lower Fraser Valley (British Columbia). ***Alberto Martilli***	**4-B-3.2** Using Laboratory Measurements and Scaling to Estimate Upwelling due to Submarine Canyons. ***Susan E Allen***
11:15	**4-B-1.4** Changes in Relative Humidity in Canada during 1953-2003. ***William A van Wijngaarden***	**4-B-2.4** Comparison of the GEM-HIMAP Precipitation Forecasts and Radar Nowcasts. ***Slavko Vasic***	**4-B-3.3** Stability and Evolution of Dense Currents on Sloping Topography. ***Joshua T Nault***
11:30	**4-B-1.5** Climate Sensitivity and Climate Change under Strong Forcing. ***GJ Boer***	**4-B-2.5** GEM – Progress Report on the Next Generation Canadian Community Model. ***Sylvie Gravel***	**4-B-3.4** Meridional Flow of Source-Driven Abyssal Currents. ***Gordon E Swaters*** **(Invited)**
11:45	**4-B-1.6** Winter Temperature Trends in Central BC Airmass Frequency and Synoptic Climatology. ***Peter L Jackson***		
12:00-13:30	**LUNCH**		

9–Bordeaux	10–Beaujolais	12–Chablis	Time
			08:30-08:35
			08:35-10:05
			08:35
			09:20
HEALTH BREAK			**10:05-10:30**
4-B-4 **Hazardous Weather VI – Tropical Cyclones & Hurricanes** *(Jim Abraham)*	**4-B-5** **Statistical Climatology** *(Raymond Wong)*		**10:30-12:00**
4-B-4.1 Modelling Trapped-Fetch Waves wit Hurricanes. ***Peter Bowyer***	**4-B-5.1** Uncertainty and Probability Analysis for Long-Term Drought Climate – based on Tree-Ring Chronologies from the Central Prairies. ***Ge Yu*** **(Invited)**		10:30
4-B-4.2 A Hurricane Climatology for Canada. ***Peter Bowyer***			10:45
4-B-4.3 An evaluation of Precipitation Distribution in Landfalling Tropical Cyclones. ***Eyad H Atallah***	**4-B-5.2** An Assessment of Statistical Downscaling Methods for Generating Daily Precipitation and Temperature Extremes in the Greater Montreal Region. ***Tan-Danh Nguyen***		11:00
4-B-4.4 Space Time empirical normal Modes Diagnostic in Hurricanes. ***Yosvany H Martinez***	**4-B-5.3** Regressional Variance Correction Method for Interpolating Daily Precipitation Data. ***Samuel SP Shen***		11:15
4-B-4.5 Atmosphere and Ocean Modelling of Extratropical Transition. ***Christopher T Fogarty***	**4-B-5.4** Application of Downscaling Techniques for Assessing Climate Change Variability and Extremes in Atlantic Canada. ***Mike Pancura***		11:30
			11:45
LUNCH			**12:00-13:30**

Time	C/D Ballrooms	5–Piesporter	7–Medeira
13:30-15:00		**4-C-1** **Atmospheric Modelling III – Climate and Data Assimilation** *(Stéphane Laroche)*	**4-C-2** **Geophysical Fluid Dynamics II** *(Bruce Sutherland)*
13:30		**4-C-1.1** Comparison of Model Performances for Leading NWP Centres. ***Tom Robinson***	**4-C-2.1** Recent Developments in the Theory of Internal Gravity Wave Breaking. ***Gary Klaassen*** **(Invited)**
13:45		**4-C-1.2** A Status Report on the Community Climate System Model (CCSM3). ***Philip E Merilees***	
14:00		**4-C-1.3** A Look at the ECMWF ERA40 Reanalysis Dataset. ***Steven J Lambert***	**4-C-2.2** An Investigation of Internal Wave Spectra using Eulerian and Lagrangian Formulations. ***Len Sonmor***
14:15		**4-C-1.4** Experimental Assimilation of SSM/I Data at MSC. ***David A Anselmo***	**4-C-2.3** Internal Wave Tunnelling through Mixed Regions. ***Bruce R Sutherland***
14:30		**4-C-1.5** Extension of 3D-Var to 4D-Var: Results from the Pre-Operational Assimilation System of MSC. ***Stéphane Laroche***	**4-C-2.4** The Effects of Moisture on Boussinesq Dynamics. ***Kyle Spyksma***
14:45			**4-C-2.5** Can Gravity-Wave Drag Parameterizations be Validated in GCMs? ***John F Scinocca*** **(Invited)**
15:00	**38th CMOS Congress – Adjourned**		

9–Bordeaux	**10–Beaujolais**	**12–Chablis**	**Time**
4-C-3 **Hazardous Weather VII** **– Hurricane Juan** *(Geoff Strong)*	**4-C-4** **Aviation Meteorology IV** **– Science Transfer and Training** *(Steve Knott)*	**4-C-5** **Atmospheric Boundary Layer** **and Air Quality** *(Peter Taylor)*	**13:30-15:00**
4-C-3.1 Aircraft Data from Rapidly-Moving Hurricane Juan South of Nova Scotia. ***Christopher T Fogarty***	**4-C-4.1** Distance Learning Aviation Courses – What's New and What's Coming from the COMET® Program. ***Vickie Johnson* (Invited)**	**4-C-5.1** Flux and Turbulence Measurements at a Densely Built-up Site in Marseille – Heat, Mass (Water, Carbon Dioxide), and Momentum. ***Tim R Oke***	13:30
4-C-3.2 Hurricane Juan – the Storm and Its Impacts. ***Peter Bowyer***		**4-C-5.2** Parameterization of the Surface Radiation Budgets of Urban Areas. ***G Doerksen***	13:45
4-C-3.3 Hurricane Juan – the Warnings and Public Response. ***Peter Bowyer***	**4-C-4.2** The NorLatMet Case Study Library – a New Resource for Operational and Research Meteorologists. ***Garry Toth***	**4-C-5.3** Analysis of Turbulence in the Urban Boundary Layer at Night. ***SM Roberts***	14:00
4-C-3.4 Peggy's Cove – Freak Wave from the East? ***Doug Mercer***	**4-C-4.3** Local Area Knowledge: Requirements for Aviation Forecasting Across Canada. ***David Aihoshi***	**4-C-5.4** Fluxes of Atmospheric Carbon Dioxide over a Suburban Environment – Observations from Vancouver. ***CJ Walsh***	14:15
4-C-3.5 The Good, the Bad, and the Ugly – Numerical Prediction for Hurricane Juan (2003). ***Ron J McTaggart-Cowan***	**4-C-4.4** Aviation Meteorology – Developing a Community of Practice: a Model for Continuous Learning. ***David B Whittle***	**4-C-5.5** The Effect of an August 2001 Russian Wildfire Smoke on $PM_{2.5}$ and Ozone in Alberta. ***Randy Rudolph***	14:30
4-C-3.6 Storm Surge of Hurricane Juan – Problems and Modelling. ***Douglas G Mercer***	**4-C-4.5** Aviation Site Reference Web Interface for Operational Forecasters. ***Kyle C Fougere***	**4-C-5.6** On Modelling the One-Dimensional Thermally Induced Slope Flows. ***Xiurong Sun***	14:45
38[th] CMOS Congress – Adjourned			**15:00**

Abstract Coding Information
Explication des codes de résumés

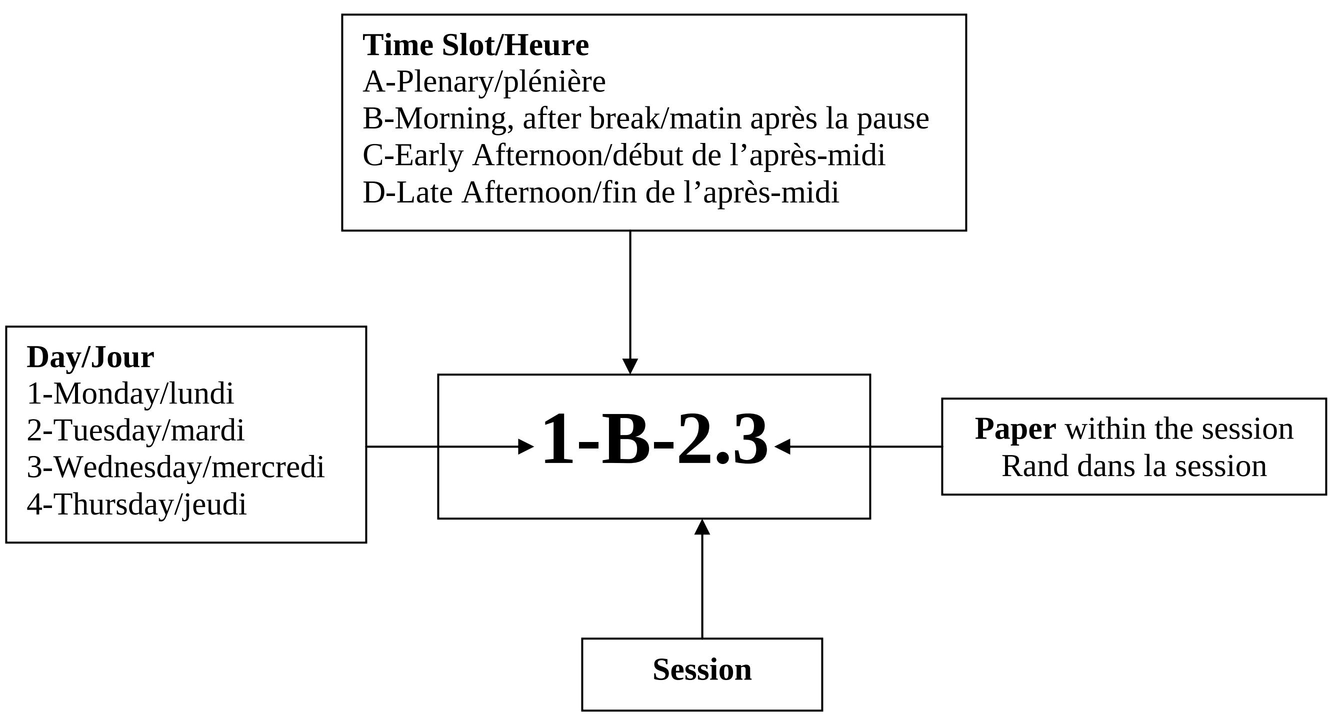
Abstract Coding Explanation
Explication des codes de résumés

Each paper has been given a unique 4-part code that serves to identify it within Congress sessions.
- Digit (1-4) denotes the day (Monday – Thursday).
- Letter (A-D) denotes the part of the day (plenary, morning, early afternoon, late afternoon).
- Letter (P) denotes a 'poster' presentation.
- Digit (1-5) denotes which parallel session it is being presented in.
- Digit (.1-n) denotes the consecutive number of the paper's time slot within a session.

Chaque présentation a reçu un code unique, compose de 4 parties pour identifier durant les sessions de Congrès'
- Chiffre (1-4) représente le jour de la semaine (lundi – jeudi)
- Lettre (A-D) représente la partie du jour (plénière, matin après la pause, début d'après-midi, fin d'après-midi)
- Lettre (P) représente une présentation 'affiche'
- Chiffre (1-5) représente la session parallèle dans laquelle se situe la présentation.
- Chiffre (.1-n) représentant le rand consecutive de la présentation durant une session.

Example: **1-B-2.3**
The paper is being presented on in the first day (1=Monday), in the second time slot (B=morning, after break), and is the third paper (.3) being presented in the second session (2) for that time slot.

Cette présentation est la troisième (.3), donnée le premier jour (1=lundi), durant le matin après le pause (B), dans la deuxième (2) session.



1-A.1 09:00-09:45 Plenary

Struck by Lightning: A Lifelong Sentence

Mary Ann Cooper, MD
Professor, Department of Emergency Medicine, University of Illinois at Chicago, ILL, USA
and Fellow of the American Meteorological Society
Contact: macooper@uic.edu

For the last 35 years in the United States, lightning has been the second highest storm killer. But only about 10% of its victims die: the rest survive, many being left with varying degrees of permanent disability ranging from brain injury to chronic pain to excessive fatigue. For many victims and their families, life, regrettably, changes forever.

With the help of the media, broadcast and U.S. national weather service meteorologists, the death rate in the last decade has been reduced 40% over predicted values and there is evidence to suggest that another 40% could be obtained if people would pay attention to the weather.

Dr. Cooper, an emergency physician and also a *Fellow* of the American Meteorological Society, will discuss mechanisms of injury, injury characteristics (which are distinctly different from electrical injuries), and the role of lightning safety education in prevention.

Conference attendees are encouraged to visit www.lightningsafety.noaa.gov to view examples of lightning safety education including lesson plans for teachers.

1-A.2 09:45-10:30 Plenary

Climate Change: How it Will Affect Natural Hazards

Gordon A McBean
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University of Western Ontario, London, ON, Canada
Contact: gmcbean@uwo.ca

Natural hazards have major impacts on Canada: from floods and droughts, ice storms and forest fires to avalanches and tornadoes. Each of these is dependent on the climate and our climate is changing. Because natural hazards are relatively rare events, it is usually not possible to attribute a specific event to climate change. However, the risks are changing and these changes need to be factored into planning and management of what we do, build and operate.

This paper will discuss recent natural hazards and their impacts and the assessments of the IPCC as they pertain to extreme events and the management of risk. Some ideas of risk management will be used in terms of decision-making approaches. It is recommended that Canada have a national hazard information and warning organization.

1-B-1.1

11:00-11:15

Is Hot and/or Dry Weather Associated with the Spreading of West Nile Virus in Canada?

Marjolijn van der Hoek, *GA McBean*, *Robert Lannigan*
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Over the last two years, West Nile Virus (WNV) and its impact on the health of Canadians has gained widespread attention and growing concern. In 2001, the virus was first confirmed in birds in the province of Ontario. The province of Ontario then confirmed the first human case of WNV in August 2001. Since then the virus has spread rapidly in Southern Canada, to the east and west of Ontario. Surveillance of mosquitoes, birds and humans has confirmed this propagation. However, although a great deal of surveillance and spraying has been done, no specific attention has been given to the possible weather-related spreading of this virus.

This presentation will discuss the ramifications for WNV spreading of specific weather conditions conducive to mosquito populations and those that affect transfer to birds, namely under hot and dry weather conditions. Specifically, migration patterns and habits of specific birds able to transfer WNV, and the habits and behaviour of WNV transmitting mosquitoes will be examined relative to measured weather conditions. The current state of knowledge will be reviewed and results from ongoing research presented. Climate change poses a real threat for the continued spread of WNV, and the relationship between weather and the virus need to be examined.

1-B-1.2

11:15-11:30

The Potential Role of High Impact Weather Events in Waterborne Disease Outbreaks in Canada, 1975-2001

MK Thomas[1], *D Charron*[2], *D Waltner-Toews*[1], *C Schuster*[3], *A Maarouf*[4], *JD Holt*[5]
(presented by ***James Valcour***)
[1]Department of Population Medicine, University of Guelph, ON, Canada
[2]Foodborne, Waterborne and Zoonotic Infections Division, Centre for Infectious Disease Prevention and Control, Population and Public Health Branch, Health Canada, Guelph, ON, Canada
[3]HPRP Project, Climate Change Effects on Waterborne Disease Risk in Canada, University of Guelph, ON, Canada
[4]Meteorological Service of Canada, Environment Canada, Toronto, ON, Canada
[5]Department of Mathematics and Statistics, University of Guelph, ON, Canada
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Adequate supply of safe water is crucial to health and wellbeing and it has recently become an issue of universal concern. Canadians have developed a heightened awareness of the risks associated with contamination in their water supply, as a result of recent disease outbreaks of *Escherichia coli* O157:H7, *Campylobacter*, and *Cryptosporidium*. This awareness has led to investigations into the causes of waterborne disease and potential risk factors including weather.

The main objectives of this research were to describe the incidence and distribution of waterborne disease outbreaks in Canada, to examine weather conditions prior to an outbreak and to test the association between high impact weather and waterborne disease outbreaks. We examined extreme rainfall and spring snowmelt in association with 169 waterborne disease outbreaks using a case-crossover methodology. Explanatory variables including daily rainfall amount, temperature, and peak stream flow were used to determine the relationship between high impact weather events and the occurrence of waterborne disease outbreaks in Canada.

Results from regression models of rainfall, temperature, peak stream flow and other explanatory variables on the likelihood of outbreak occurrence will be presented. Knowledge gained from this research could contribute to better-informed policy decisions to deal with current concerns of waterborne disease and to develop adaptive strategies for enhanced public health and safety under future climate change conditions. With global warming, Canada is projected to experience milder winters, longer summers, drier summers in many populated areas and more events of intense precipitation. These changes in Canada's climate could potentially impact the incidence of waterborne disease in the future.

1-B-1.3 11:30-11:45

Impact of Climate and Agriculture on Enteric Illness in Atlantic Canada: Toward a Climate Change Adaptation Strategy

James E Valcour[1], *David Waltner-Toews*[1], *Dominique F Charron*[2], *Olaf Berke*[1], *Tom Edge*[3], *Corinne Schuster*[4]
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[2]Health Canada, Guelph, ON, Canada
[3]National Water Research Institute, Environment Canada,
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Canadians are fortunate to have access to an ample supply of fresh drinking water. Recent outbreaks of waterborne illness in Walkerton, ON (McQuigge, 2000) and the Battlefords, SASK (Hrudey and Hrudey, 2002) have brought issues of access to clean drinking water to the forefront of public concern in Canada. Bacterial and protozoan pathogens have the potential to contaminate food supplies, sources of drinking water, waters for agricultural uses (such as irrigation and livestock), recreational waters and aquaculture. During the period from 1974 to 1996, over 200 outbreaks of enteric illness were attributed to drinking water (Environment Canada, 2001).

The major pathogens involved in waterborne enteric illness include *Escherichia coli*, *Salmonella* spp., *Campylobacter* spp., *Giardia lamblia* and *Cryptosporidium parvum*. Several of these pathogens have been related to agricultural activities. An association between cattle density and the incidence of Shiga-toxin producing *E. coli* (STEC) has been demonstrated (Valcour et al., 2002; Michel et al., 1999). An association has also been seen between the application of manure to the surface of cropland and the incidence of human STEC infections in Ontario (Valcour et al., 2002). Irrigation of cropland with animal waste has also resulted in foodborne outbreaks of *Salmonella* spp (Cliver and Atwill, 1997).

Climate change is a sustained departure from previous normal weather patterns and has been associated with an accumulation of greenhouse gases (GHG) in the upper atmosphere. This results in a warming of the lower atmosphere and increased variability in local weather patterns. It is projected that temperature in Atlantic Canada could increase 3-4°C in the next 100 years. This could result in higher pathogen replication and survival, increased host susceptibility to infection and increased pathogen shedding from infected livestock. Higher precipitation levels are also projected which could result in higher levels of run-off from agricultural land, which can contaminate of local water supplies. Extreme weather events (such as flooding) can damage water treatment infrastructure and/or cause flooding that would result in contamination of surface waters and wells.

This study will describe temporal and spatial trends in cases of enteric illness in Atlantic Canada and examine the relationship between weather parameters (temperature and precipitation) and the number of cases of enteric illness in Atlantic Canada accounting for temporal and spatial clustering.

1-B-1.4 — 11:45-12:00

Seasonal Trends in Temperature and Foodborne Illness

Manon D Fleury[1], *Dominique Charron*[1], *John Holt*[2], *Brian Allen*[2], *Abdel Maarouf*[3]
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Seasonal variation in the incidence of enteric infections in the Canadian population is thought to be primarily due to warmer ambient temperatures in summer. In order to further explore this hypothesis, and to define the effect of ambient temperature on the occurrence of enteric disease, we investigated the seasonal patterns of the enteric pathogens *Salmonella, Campylobacter* and *E. coli*, in Alberta and Newfoundland-Labrador between 1992 and 2000. The project examined the relationship between weekly occurrence of enteric illness and average ambient temperature, looking particularly at the effect of seasonal adjustments on the estimated models.

This paper explores different types of methodology for the analysis of time series of counts using generalized additive models and generalized linear models with regression splines. These methods are becoming widely used for environmental time series analyses because they permit flexible adjustments for non-linear confounding effects of time variations, seasonality and weather variables. Preliminary results indicate a strong non-linear association, beyond seasonal effects, between ambient temperature and the occurrence of three enteric infections in Alberta. Results from the analyses of the data from Newfoundland-Labrador did not show the same pattern. Further analysis using zero-inflated methods should be considered for this and other provinces with small populations. To conclude the association between temperature and enteric diseases is important to consider in light of future climate change projections.

1-B-1.5 — 12:00-12:15

Climate Warming and Emerging Infectious Diseases in Arctic and Sub-Arctic Wildlife

Susan J Kutz[1], *Emily E Jenkins*[1], *Alasdair Veitch*[2], *John Nishi*[2], *Brett Elkin*[2], *Lydden Polley*[1]
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Global warming, one of the most important drivers of emergence of disease in people and domestic livestock, is anticipated to have significant impacts on the occurrence of disease in arctic and sub-arctic wildlife. Many pathogens of wildlife have life stages that develop in the environment or require invertebrate vectors for transmission. At northern latitudes these pathogens are typically constrained by the long cold winters and short, cool summers, and climate warming is expected to relax some of these constraints and alter the epidemiology of the pathogen.

A simple predictive model for parasite development rates in the Arctic, based on degree days, was developed from laboratory data and validated by field experiments on *Umingmakstrongylus pallikuukensis*, a unique lungworm of muskoxen. This model indicates that in unusually warm summers the transmission cycle of this gastropod transmitted nematode will be reduced from two years to a single year. A similar degree-day model successfully predicted development rates of *Parelaphostrongylus odocoilei*, a related muscle-dwelling nematode in Dall sheep, in a sub-arctic mountain environment.

To understand, predict, monitor, and possibly mitigate the impact of climate change on infectious diseases in northern wildlife and people, it is essential to first address the numerous knowledge gaps with respect to the diversity, life cycles, geographic and host ranges, effects, and sensitivity to climate change of pathogens in the north.

In this presentation we use examples to demonstrate the possible effects of climate change on northern host-pathogen relationships and discuss a new initiative to identify and address potential vulnerabilities in the health of caribou related to climate change and infectious disease.

1-B-2.1 11:00-11:15

Sea-Ice Representation in Global Climate Models

Gregory M Flato
Canadian Centre for Climate Modelling and Analysis, Meteorological Service of Canada (MSC), University of Victoria, BC, Canada
Contact: greg.flato@ec.gc.ca

The Coupled Model Intercomparison Project (CMIP) has assembled climate model output from control integrations and experiments in which CO_2 increases at a rate of 1% per year for 80 years. Results from these models are compared to illustrate differences between model simulations of contemporary sea-ice extent and thickness, and the response of sea ice to climate warming. The model results are categorized in terms of model attributes like their use of ‘flux adjustment’ or their representation of sea-ice dynamics. However, no connection is apparent between model errors and these attributes. Positive feedbacks involving sea ice lead to an amplification of greenhouse-gas induced climate warming at high latitudes. These feedbacks also amplify model errors. We find no evidence of correlation between model biases and the modelled sea-ice response, and only weak evidence of a dependence of temperature response to sea-ice biases.

1-B-2.2 11:15-11:30

Simulation of Sulphate Size Distributions in the CCCma GCM

Xiaoyan Ma, *Knut von Salzen*
Canadian Centre for Climate Modelling and Analysis, Meteorological Services of Canada (MSC), University of Victoria, BC, Canada
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The optical properties of aerosols and their effects on clouds depend strongly on the size distributions of the aerosols. Currently, Atmospheric General Circulation Models (AGMs) only include relatively simple representations of aerosol/climate feedback processes, without any explicit treatment of aerosol size distributions. A physically-based approach for simulations of aerosol size distributions is currently being implemented in the latest version of the CCCma AGCM. Newly added processes include hygroscopic growth of sulphate aerosols, nucleation/condensation, coagulation, in-cloud production, and wet and dry deposition.

Results of the newly developed model version are compared to results from the original version of the model, which only includes a bulk sulphur cycle. If the same treatments of gas- phase chemistry, in-cloud chemistry, wet deposition and dry deposition are used in both versions of the model, a higher sulphate burden is simulated in the model version that includes parameterizations for size-segregated aerosols. Tests show that the differences in sulphate burdens are caused by different treatments of gas-to-particle conversion and advection in the models. Additional sensitivity tests give evidence that the dry deposition schemes have a significant influence on the simulated sulphate burdens. The application of the original dry deposition scheme from the bulk sulphur cycle leads to 20-30% higher sulphate burdens compared to the size-dependent approach. The dry deposition scheme also has a marked effect on the simulation of the sulphate mass mean diameter. Results obtained with the size-dependent scheme are expected to be more realistic since it is based on more detailed physical assumptions and explicitly accounts for the effects of gravitational settling, surface resistance, and resistance over canopy.

1-B-2.3 11:30-11:45

Global Circulation of Mercury in a Numerical Weather Model

Ashu P Dastoor, *Didier Davignon*
Meteorological Service of Canada (MSC), Environment Canada, QC, Canada
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Unlike other heavy metals, mercury transforms and transports at short to long space and time scales rendering it a regional to global scale pollutant. 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 implying a long life time of mercury in the atmosphere (~ one year). On the other hand, in recent years several experimental studies have shown that under certain conditions such as present during spring-time in the Arctic region, elemental mercury could transform and deposit to the surface with-in few hours to days.

At Meteorological Service of Canada (MSC), utilizing the Canadian operational weather prediction model, we have developed a multi-scale Global/Regional Atmospheric Heavy Metals Model (GRAHM) to address the questions such as budgets, long-range transport, trans-boundary exchanges and polar pollution related to mercury in the atmosphere. 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 the horizontal, the model is used for simulations from regional to global scales 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 to estimate the global mercury budgets, to establish continental scale source-receptor relationships for policy strategies and to understand the role of the Arctic depletion events of mercury on the globe. Model description, its capabilities and results from the above mentioned studies will be presented at the meeting

1-B-2.4 11:45-12:00

The Greening of the McGill Paleoclimate Model, Part I: Improved Land Surface Scheme with Vegetation Dynamics

Yi Wang[1], *Lawrence A Mysak*[1], *Zhaomin Wang*[1], *Victor Brovkin*[2]
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[2]Potsdam Institute for Climate Impact Research (PIK), Potsdam, Germany
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The formulation of a new land surface scheme with vegetation dynamics for coupling to the McGill Paleoclimate Model (MPM) is presented. The new land surface component incorporates significant improvements over the old version used in the MPM, which can be summarized as follows: (i) parameterization of deciduous and evergreen forests by using the model's climatology and the output of the dynamic global vegetation model VECODE, developed by Brovkin et al. (1997); (ii) parameterization of tree leaf budburst and leaf drop by using the model's climatology; (iii) parameterization of the seasonal cycle of the grass leaf area index; (iv) parameterization of the seasonal cycle of tree leaf area index by using the time-dependent growth of the leaves; (v) the calculation of land surface albedo by using vegetation-related parameters, snow depth and the model's climatology. The results show considerable improvement of the model's simulation of the

present-day climate as compared with that simulated in the original physically-based MPM. In particular, the strong seasonality of terrestrial vegetation and the associated land surface albedo variation are in good agreement with several satellite observations of these quantities. The first application of this new version of the MPM to Holocene millennial-scale climate variability is described in a companion paper, Part II.

1-B-2.5 12:00-12:15

Large-Scale Ice Discharge Events in a Pure Ice Sheet Model

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Sediment cores in the North Atlantic show evidence of periodic large-scale ice discharge events between 60 ka and 10 ka BP. These events occurred with a typical period between 5 kyr and 10 kyr. During each event, a significant amount of ice was discharged from the Hudson Bay region through the Hudson Strait and into the North Atlantic. This input of freshwater through the melting of icebergs is thought to have strongly affected the Atlantic thermohaline circulation. One theory is that these periodic ice discharge events represent an internal oscillation of the ice sheet under constant forcing. A second theory requires some variable external forcing on an unstable ice sheet to produce a discharge event. Using the ice sheet model of Marshall, an attempt is made to simulate periodic large-scale ice discharge events within the framework of the first theory. In this case, ice sheet surges and large-scale discharge events occur as a free oscillation of the ice sheet. An analysis of the activation of ice surge events and the thermodynamic controls on these events is also made.

1-B-2.6 12:15-12:30

Simulation of the Last and Next Glacial Inceptions with the Green McGill Paleoclimate Model

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A fundamental question in Quaternary science is to determine when the present interglacial will end and when the next ice age might occur. Whereas scientists predicted an imminent glaciation in the 1970s, it seems today that the present interglacial may last longer, due to an exceptional configuration of the future variations of the summer solar insolation at northern high latitudes. The McGill Paleoclimate Model, with its recently added vegetation component, has first been run to simulate the climate of the past (from 122 kyr to 80 kyr BP), i.e., the last glacial inception. Results show a glacial inception around 117 kyr BP followed by a rapid building of ice sheets over North America, and a slower increase of ice volume over Eurasia. The model has then been run to simulate the short-term future with various increasing atmospheric CO_2 concentrations, to find the possible responses to global warming. The results are quite similar to those obtained by GCMs, and lie in the IPCC range of results. Finally, the model has been run to simulate the climate of the next 100 kyr, i.e., the next glacial inception, with different scenarios for the atmospheric CO_2 concentration, both constant and variable. We shall present the thresholds in carbon dioxide concentration that will determine the occurrence or absence of glacial inception in 50 kyr.

1-B-3.1 11:00-11:15

Shoaling Waves Experiment – Air-Sea Interaction in a Coastal Region

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Wind, temperature and wave parameters were measured from ships and buoys during the SHoaling Wave EXperiment (SHOWEX) in the fall of 1999 on the continental shelf N of Cape Hatteras in widely varying atmospheric conditions and water depths. It was a joint project among project leader, RSMAS, Fisheries and Oceans Canada, and several other government and research institutes in Canada and the USA. A large set of meteorological and directional wave data were gathered from the Canadian swath vessel CCGS Frederick G. Creed and nearby buoys. These data are being used to determine differences between shipboard and buoy mounted measurements and between eddy-correlation (direct) and dissipation (indirect) wind stress estimates. The experiment was designed to measure the momentum and energy input to the wave field during active wind-wave growth and simultaneously the momentum and energy flux from air to sea. We will present and interpret the extensive and well-calibrated set of wind and temperature data and wind stress (using the turbulent dissipation and eddy correlation techniques).

1-B-3.2 11:15-11:30

On the Air-Sea Coupling Coefficients for Momentum, Heat and Mass in High Winds

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The mechanical and thermodynamic coupling between air and sea has been the subject of much study in the last half century, and semi-empirical expressions for the bulk coupling coefficients of momentum, heat and moisture – drag coefficient, Stanton and Dalton numbers – are in common use in weather forecasting and climate prediction models. For the most part these coefficients are derived from field observations and can be considered to be well established in the wind speed range of 5 m/s to 20 m/s. At higher wind speeds data are too scarce and estimates too scattered to provide any confidence in the value of these coefficients. Yet coupled modeling of the atmosphere and oceans in severe storms depends on correctly representing the flux of momentum and energy across the air-sea interface in winds well above 20 m/s and perhaps as high as 100 m/s. The water surface undergoes several transitions in its geometric properties as the wind speed increases: from calm to ripples to waves to whitecaps to spray as the wind crosses approximate thresholds of 2 m/s, 4 m/s, 6 m/s, 25 m/s. These marked changes in the nature and magnitude of the “roughness” of the surface may be reflected in the bulk transfer coefficients.

In this paper we report on laboratory experiments to investigate the character of the bulk transfer coefficients for momentum, heat and moisture in the wind speed range (referred to 10 m height) of 1 m/s to 55 m/s. The results of the laboratory experiments are compared with the sparse high wind field observations.

1-B-3.3 11:30-11:45

Tsunami Heights and Currents from a Cascadia Megathrust Earthquake

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The 1700 Great Cascadia Earthquake (M=9) generated a widespread tsunami which affected the entire Pacific Ocean and caused damage as far as Japan. Estimated from paleotsunami studies, tsunami wave heights in some bays and inlets of the coast of Vancouver Island were up to 20 m. Seismological data indicate that the major earthquakes (M > 9) in the Cascadia Subduction Zone occur every 500 years. Similar catastrophic waves may be generated by a future Cascadia earthquake. We use a plausible 1100-km long rupture scenario of such earthquakes to estimate possible wave heights and maximum currents in inlets, bays and harbours of Vancouver Island. We present the tsunami model results for several sites, including Victoria, Esquimalt, Sooke and Ucluelet harbours. In some shallow bays the modelled tsunami heights exceed 15 m, while in narrow channels the maximum tsunami currents can be as high as 30 knots.

1-B-3.4 11:45-12:00

Nearshore Wave Attenuation during Hurricane Juan

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The significant wave heights generated by Hurricane Juan exceeded 9 m along the coast of Nova Scotia, in excess of the expected 100-year extremes for this region. These waves were observed in nearshore areas, including the mouth of Halifax Harbour (buoy 44258), and outside Lunenburg Bay (BIO directional wave rider, DWR). Proceeding shoreward, the Juan waves experienced dynamic interactions with the bottom as they attenuated, but still contained appreciable energy relatively close to shore. Lunenburg Bay waves, detected at the DWR in 37 m depth water, were also measured closer to shore by a directional wave package on an ADCP (acoustic doppler current meter), in 18 m depth water. The former saw 9 m peak Hs, the latter peaked at 5 m. In fact, consistent attenuation of 35-50% was observed between the two sites (separated by 9 km) as the storm passed.

A state-of-the-art operational shallow water wave model (SWAN) was implemented on a very fine resolution grid of 600 m for Lunenburg Bay, nested within successively coarser resolution grids, covering Scotian Shelf, Atlantic Canada waters, the NW Atlantic, and the entire Atlantic, with WaveWatch wave model implemented for the coarsest three of these grids. The composite model system was used to hindcast the waves of Hurricane Juan, using standard 6-hourly operational winds from the US Navy COAMPS, at 0.2 deg resolution for the NW Atlantic, nested within NOGAPS winds at 1.0 deg resolution for the rest of the Atlantic. Tests and comparisons of the composite SWAN-WaveWatch model system are presented, in comparison with the in situ data from the DWR and ADCP moorings. Observations of peak waves from this storm are used to inter-compare the capabilities of the wave models to simulate extreme waves on extreme shallow waters. Moreover, Juan also provides a unique data set to consider the capabilities of the DWR and ADCP instruments to measure those waves in shallow waters. Wave energy dissipation from deep water to shallow water and wave model skill will be discussed using simulations and observations.

1-B-3.5 12:00-12:15

Blending Parametric Hurricane Surface Fields into CMC Forecasts and Evaluating Impact on Storm Surge for Hurricane Juan

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Currently, the operational storm surge model is driven by the Regional GEM forecast surface fields (10 m wind and surface pressure). Generally, when these forecast fields are good then the operational storm surge model also produces a reliable sea level forecast. However, the present operational data assimilation and forecast system often has difficulty representing and predicting hurricanes, leading to poor forecasts when the surface fields around the hurricane are used as input for a wave or a storm surge model. In search of practical improvements in the shorter term, here we propose to blend parametric hurricane wind and pressure fields based on the Canadian Hurricane Centre trajectory forecasts into the operational surface fields used as input for the storm surge model. Here we present the plan of the project as well as some results for Hurricane Juan as a proof of a concept. Sea level simulations are performed using a simple storm surge model forced by a parametric wind field only. Results from the simulations are compared with a few tide gauge observations. Then sea level simulations are also produced using the operational storm surge model and the operational surface fields blended with parametric hurricane surface fields and the results are compared for Hurricane Juan.

1-B-3.6 12:15-12:30

Evacuation in White Bay, Newfoundland during the Winter Storms of 1989 and 2004

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On January 16, 2004, the entire community of Beaches, in White Bay, Newfoundland, was evacuated when strong seas and high water levels led to domestic flooding during an intense winter storm. Another storm on January 5, 1989 resulted in similar flooding and evacuation – in that storm a front-end loader was dispatched to remove boulders from the main road. These events are studied to determine commonalities in storm path and intensity and with respect to wind speed, direction and duration. Tidal patterns, local bathymetry and the climatological database are also investigated. In an effort to provide forecasters with the capacity to warn emergency officials, the conditions necessary to generate these flooding events are proposed.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00

**complete abstracts cited under Poster Session, pp. 167-178*

P-1 (1-B-3)

Effect of Vessel Type and Platform Relative Wind and Wave Direction on the Comparison between Ship and Buoy Winds. ***Bridget R Thomas***, *Val R Swail* (Climate Research Branch, Meteorological Service of Canada (MSC), Dartmouth, NS, Canada)

1-B-4.1 11:00-11:15

NAV Canada and Meteorological Service of Canada: Aviation Performance Measurements, Trend Analysis and the Future

Henry Stanski, *Kent Johnson, Ken Little*
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Aerodrome forecasts in Canada are produced by the Meteorological Service of Canada (MSC) under a commercial agreement with Canada's air navigation service, NAV CANADA. This agreement requires that MSC generate various performance measures and meet specific performance standards. The aviation performance measurement program began in 1997 and consists of a suite of scores that focus on significant ceiling and visibility thresholds and TAF amendment timeliness. These scores are summary in nature and thus provide an indication of the overall health of the forecast system. Each score is a window that spotlights different aspects of the aerodrome forecast and objectively quantifies accuracy such that safety is maintained and value is rendered to the aviation community. The performance scores were selected such that forecasters are encouraged to issue the best forecast possible and not simply aim for the best score.

The NAV CANADA/MSC aviation performance measurement system has been operational since early 1997. The first six-hours of every TAF is verified minute-by-minute for three performance measures: VFR (Visual Flight Rules) Reliability, Alternate Reliability and the False Alarm Ratio for Below Alternate Landing Conditions. These performance measures are available by individual aerodrome or collectively for 173 aerodromes across Canada.

1-B-4.2 11:15-11:30

Trends on the Usage of Groups (TEMPO, FM) in Aviation Aerodrome Forecasts (TAFs)

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The Meteorological Service of Canada monitors and reports on the performance of Aerodrome Forecasts (TAFs) in order to meet contractual obligations to NAVCANADA. The TAF performance measurement database now covers a period in excess of 6 years, which allows for studies of a significant duration to establish meaningful trends. The data were analyzed for the frequency of use, in the first 6 hours, of TEMPO, PROB30, PROB40, BECMG and FM. The data were stratified by year and season to establish trends.

1-B-4.3 11:30-11:45

Wind Profiler in Airport Environment

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Nice airport, in southern France, is located in a densely populated area, on land reclaimed from the sea. The airport is situated at an intersection between the sea, the Alps and a river. This can be at times a difficult environment for airport operations. Using the wind profiler, the evolution of the wind field associated with mixing of air masses above the airfield can be tracked in real time, and thus allow controllers to adapt airport movements to best suit conditions. Several examples of wind shear associated with the evolution the air mass boundaries are presented, along with the

associated real time automatically generated wind shear warning messages. The wind profiler can also furnish boundary layer height evolution.

1-B-4.4 11:45-12:00

Progress on the Development of the Canadian Aircraft Meteorological Data Relay (AMDAR) Program

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The Canadian AMDAR Program is the main component of the modernization of the Canadian Upper Air Program. It is an ambitious program with development proceeding simultaneously on three fronts: a conventional ACARS-based system for Jazz aircraft servicing southern Canada; an Iridium LEO/TAMDAR/Internet-based system for First Air servicing northern Canada; and an AFIRS/UpTime-based AeroMechanical Services system for the tiny regional airlines to fill in data poor areas. Furthermore the requirement for redundancy and backup is recognized such that much effort is made to enroll Air Canada, WestJet and Canadian North. Progress on the overall development of the Canadian AMDAR Program and results from R&D studies will be presented. Also the US NOAA Forecast Systems Laboratory (FSL) recently implemented a tephigram representation of ACARS/AMDAR data on their website (http://acweb.fsl.noaa.gov/java/) for users, such as Canadians, of tephigrams instead of SkewT. The tephigrams have all the same real-time functionality of the SkewT plots: i.e., they are zoomable, the user can use interactive parcel trajectories, etc. This system will be demonstrated as well.

1-B-4.5 12:00-12:15

Flight Test Results from a New AMDAR System

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The Automatic Flight Information Reporting System Model 220 (AFIRS 220), developed by AeroMechanical Services Ltd. (AMS) of Calgary, Alberta, is an autonomous flight data collection and reporting system designed for a number of commercial aircraft applications. These applications include flight position reporting, systems maintenance monitoring, global operational fleet management, and operational safety coordination. The AFIRS 220 records all data from the aircraft Flight Data Acquisition Unit, as well as GPS position, and additional discrete sensor signals. Selected parameters from the AFIRS 220 can be formatted into a standard AMDAR (Aircraft Meteorological Data Relay) reports, consisting of PA, OAT, WS, and WD. These AMDAR reports can be transmitted in real time throughout the aircraft's various phases of flight. AMS is working with AES to evaluate the utility of these AMDAR reports from Canada's "meteorological data-sparse regions" to augment the upper-level observation network. Vertical atmospheric soundings at selected airports, as well as cruise profiles along selected flight tracks and altitudes, are being evaluated for inclusion in numerical forecast models. Results from these various AMDAR tests will be presented in detail, and the implications to the aviation and meteorological communities will be discussed.

1-B-5.1 11:00-11:15

ELBOW 2001: Analysis of Low-Level Boundaries in Southwestern Ontario

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The Effect of Lake Breezes On Weather (ELBOW) 2001 field project was conducted in the summer of 2001 in order to better understand the role that lake breezes play in convective initiation and severe storm development in Southwestern Ontario. Data such as surface mesonet, radiosonde, Exeter radar, and satellite collected during ELBOW 2001 have been used to locate low-level boundaries, such as lake breeze fronts and gust fronts, throughout the 29 intensive observation days of the study. From this analysis, it is clear how frequently these low-level boundaries are present in the area. We are now investigating how much influence these boundaries have on summer severe storms in the Great Lakes Region.

1-B-5.2 11:15-11:30

Regional Evapotranspiration and Moist Deep Convection on the Canadian Prairies

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Moist deep convection (i.e., the formation of cumulus congestus and cumulonimbus clouds with showers, thunderstorms, and associated locally severe weather including flooding rains, hail and tornadoes) results from the explosive release of convective available potential energy (CAPE) when a dynamic mechanism lifts boundary layer air parcels to their level of free convection. Regional evapotranspiration contributes to moist deep convection in three ways: (1) by moistening the atmospheric boundary layer, it enhances the convective available potential energy (CAPE) which increases the probability-of-occurrence and intensity of moist deep convection, (2) it adds water vapour (mass) to the atmosphere which may fall as rain within the same region (recycled rain), and (3) its spatial discontinuities may induce meso-scale thermal circulations that can trigger moist deep convection.

In the cropped grassland eco-climatic region of the Canadian Prairies, cumulus convective rainfall is a significant component of the hydrologic cycle, and moist deep convection is a prime source of summer severe weather. The influence of the seasonal development of the dominant vegetation, annual field crops, upon the partitioning of the net radiation between latent and sensible heat flux, and consequently, upon CAPE and the probability-of-occurrence and the intensity of thunderstorms, is demonstrated by the strong linkage between crop phenology and the seasonal pattern of tornado days. Regional moisture flux is also an important source of water vapour mass for warm season rainfall.

The summer recycling ratio for the cropped grassland region has been estimated to be 25-30%. It follows that, evapotranspiration, which not only requires moisture in the root zone but also vegetation to transfer that moisture to the atmosphere, is a necessary, though not sufficient, condition for an active convective season. Spatial heterogeneity in rainfall, vegetation type and/or crop stage within the cropped grassland region may produce differences in latent heat flux and,

thus, sensible heat flux discontinuities. Over higher-sensible-heat-flux (i.e., lower-latent-heat-flux) areas, the convective boundary layer grows deeper relative to lower-sensible-heat-flux (i.e., higher-latent-heat-flux) areas. Meso-scale thermal circulations may arise to equalize these differences. During periods of weak synoptic forcing, these land-land breezes can provide the trigger for moist deep convection by lifting boundary-layer air parcels to their level of free convection

1-B-5.3 11:30-11:45

The Dryline as a Mechanism for Severe Thunderstorm Initiation on the Canadian Prairies

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Surface observations and remote sensing data are used to demonstrate the role of the dryline in initiation of severe thunderstorms on the Canadian prairies. Synoptic and mesoscale conditions preceding dryline development are identified and a proposed mechanism for dryline genesis and evolution is presented. This work is motivated by a lack of documentation of the dryline in Canada and a need for Canadian Prairie forecasters to understand its significance, development, and behaviour.

Within Alberta and Saskatchewan from 1 May to 30 September 2000, 33 days were identified as having three or more reports of 20 mm hail or at least one report of 30 mm hail and/or a tornado. On 17 of these ‘severe’ days, thunderstorms were either initiated in close proximity to, or interacted with, a dryline. Plots of dryline position, thunderstorm tracks, and severe weather event locations support the concept of the dryline as a mechanism for convective initiation and illustrate its significance for severe weather forecasting.

The dryline develops in response to convergence of moist prairie air with dry, subsiding air in the lee of the Canadian Rockies. Its presence is most readily observed via strong gradients in surface dew point temperature, convergence lines in the surface wind field and cumulus development on satellite imagery. Southern portions of the dryline often bulge eastward in response to entrainment of dry air aloft and mixing of momentum associated with an axis of strong mid-level winds. The dryline is thus classified as quasi-stationary (QS) or bulging (B) depending on the degree of bulging it exhibits. In rare cases, storms initiated on a western portion of the dryline may become tornadic as they interact with a bulging portion of the dryline. Through recognition of antecedent synoptic and mesoscale conditions, the forecaster can anticipate dryline development well in advance and thus identify a preferred axis for thunderstorm initiation.

1-B-5.4 11:45-12:00

The Pre-Storm Capping Lid and Dryline during A-GAME 2003

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Radiosonde soundings were released at three central Alberta sites during July-August 2003 in order to obtain preliminary data to evaluate GPS moisture data retrieval for meteorological purposes. Evaluation of a 16-site GPS receiver network operated by the University of Calgary on an average 50-km baseline is the primary goal of A-GAME (Alberta GPS Atmospheric Moisture Evaluation). However, A-GAME also provides an excellent opportunity to obtain the first detailed information on severe thunderstorm processes over Alberta foothills since the Limestone Mountain Experiment (LIMEX-85) of July 1985. As with its predecessor, A-GAME thunderstorm objectives focus on the pre-storm and storm initiation boundary layer.

Results for several thunderstorm cases will be discussed, using sounding profiles and high temporal resolution GPS precipitable water estimates, and 2.5-km GEM model runs. Additionally, some rather surprising results from surface transects across the dryline and capping lid over Alberta foothills will be discussed, using both mobile transect and fixed network data. The 2003 results provided some validation of proposed revisions to the multi-scale thunderstorm model.

1-B-5.5 12:00-12:15

Local Initiation of Deep Convection on the Canadian Prairies

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This study demonstrated that it is likely that local mesoscale circulations associated with highland areas, and transient evapotranspiration discontinuities influenced the timing and location of the initiation of deep convection across the Canadian prairie provinces when synoptic-scale forcing is weak (e.g., weak low level winds and no frontal boundaries). The cumulus congestus and cumulonimbus clouds that formed over the highland areas were initiated by anabatic wind induced mesoscale circulations. These deep convective clouds generally formed relatively early in the day (about 1030 Central Standard Time (CST)). In the relatively flat cropped grassland region, transient evapotranspiration gradients influenced the location of deep convection initiation, and the average soil moisture in the root zone had a direct impact on their timing. As root zone soil moisture declined from greater than 70% to less than 30%, convection initiation was delayed from about 0930 to 1630 CST. Cumulus congestus and cumulonimbus clouds that formed over the ephemeral evapotranspiration gradients were initiated by land-land circulations. This study has improved the understanding of the influence of local surface forcing on the development of deep convective cloud on 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.

1-B-5.6 12:15-12:30

HAILCAST as an Operational Forecast Tool – Performance for Three Severe Hail Events over the Canadian Prairies

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During the summer of 2003, the HAILCAST model (Brimelow et al., 2002, *Wea. Forecasting*, 1048-1062) was run operationally over the Prairie Provinces by the Meteorological Service of Canada. Hail-size forecast maps, valid for 21Z and 00Z, were generated each day by running HAILCAST at each point on a Cartesian grid of almost 1 500 GEM forecast GRIB soundings (from the 12Z GEM model run). Three severe hailstorms, that produced hail up to 9 cm in diameter, were observed on 2 July, 11 August and 12 August. Fortuitously, samples of large hail were obtained for all three events, thereby affording us to the opportunity to directly compare the model forecast maximum hail sizes with the observed maximum hail sizes. The three events were used to examine the operational utility of coupling the GEM model soundings with the HAILCAST model to predict maximum hail size up to 12 hours in advance. Our hail forecasting technique was found to provide valuable guidance for predicting both the location and maximum size of the hail for all three events. We also consider the utility of employing prognostic fields of 700 hPa vertical motion to exclude areas where hailstorms are not expected. We will discuss details of the pre-storm environment and subsequent thunderstorm activity for each case, and present preliminary results from an analysis of thin sections from selected hailstones.

1-C-1.1 14:00-14:15

Predicting the Risk of Freezing due to Wind Chill

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A dynamic model of facial cooling was developed in conjunction with the release of the new Wind Chill Temperature (WCT) index. Whereby the WCT provides wind chill estimates based on steady state considerations, the dynamic model can be used to predict the rate of facial cooling, and particularly the onset time of freezing. In this presentation, the dynamic model is applied to various combinations of air temperature and wind speed, and predictions of the resultant steady state cheek skin temperatures are demonstrated.

For combinations of air temperature and wind speed that result in the same WCT, the initial rate of change of skin temperature is higher for those combinations having higher wind speeds. For example, combinations of - 45°C and 5 km×h-1, and - 35°C and 35 km×h-1 wind result in a common WCT of -53°C, yet the predicted risk of freezing is < 5% for the former case and freezing is predicted to occur within 6 minutes in the latter case. This suggests that during short exposures, high winds combined with low temperatures might be perceived as more stressful than light winds with lower temperatures that result in the same ‘wind chill’.

Also discussed is the paradox that individuals having a low cheek thermal resistance are predicted to experience a more severe WCT, but are at less risk of cooling injury than individuals with higher cheek thermal resistances. The dynamic model is further applied to predict the onset of finger freezing. Guidance on the risk of finger freezing is important not only to safeguard the finger, but also because it pertains more closely to susceptible facial features, such as the nose, than if only the risk of cheek freezing was provided. Results indicate that the surface of the finger cools to its freezing point in approximately one-eighth of the time predicted for the cheek. The advantages of cooling time predictions using the dynamic model are discussed with the recommendation that the reporting of onset times to freezing, or safe exposure limits, are more meaningful and less ambiguous than the reporting of the WCT. A relatively simple forecast of the risk of freezing is suggested using a numeric scale analogous to the UV index.

1-C-1.2 14:15-14:30

Renewed UV Index Program in Canada

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Environment Canada has renewed its UV Index forecast program for the spring of 2004, bringing the program in line with the new global UV Index guidelines of the World Health Organization. The forecast methodology for the UV Index will take into account elevation and reflection of UV radiation by snow on the ground, two factors not included before. In addition, the scheme to determine the UV index based on observations from Brewer spectrophotometers has been improved and will result in a 5-10% increase in UV Index values. These changes will also result, particularly in the spring, in a forecast UV index that will be higher than in the past, especially when fresh snow is present. Moreover, the criteria used to include the UV index in public forecasts

have been modified. The UV index is now included in the forecast, rounded off to the nearest whole number (no decimals), whenever it is forecast to be of 3 or more, regardless of the season. This means that under certain conditions the UV index could appear in winter. This also means that it may not appear on heavily overcast or rainy days during the summer.

In accordance with international recommendations, the categories of the UV index are now the following: low: 0 to 2 (formerly 0 to 3.9); moderate: 3 to 5 (formerly 4 to 6.9); high: 6 and 7 (formerly 7 to 8.9); very high: 8 to 10 (new category); extreme: 11 and higher (formerly 9 and higher). Finally, the renewal of the Canadian UV Index program is being done in co-ordination with the renewal of the American UV Index Program.

1-C-1.3 14:30-14:45

Potential Climatic Indicators for Water Contamination and Consequent Drinking Water Disease Outbreaks

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Disease outbreaks occurring in drinking water has become a high profile issue in Canada since the *E. coli* O7:H157 outbreak which occurred in Walkerton in 2000. Public Health Officers and water users would like to better assess potential risks with higher accuracy in order to issue boil water advisories and other warnings in a timely and accurate manner. Research undertaken in the U.S. has demonstrated a link between high precipitation events and waterborne disease outbreaks.

The majority of contaminants which end up in the water are not directly deposited there. Most contaminants are deposited on, or just beneath, the ground within a catchment as a result of domestic and wild animals, agricultural practices, human activity, urban pollution and aeolian processes. A mechanism must exist to relocate contaminants into a drinking water source. In the case of biological contaminants, this transfer has to occur in a timely manner, so that pathogenic organisms remain viable and infective. The main mechanism for this contaminant transfer is overland flow. Shallow sub surface flow and surface water incursion will add to this, but the process of water draining through the soil will filter out some contaminants or add enough travel time so that they are no longer viable. Overland flow will occur when the ground is saturated from previous heavy rainfall or snowmelt; the ground is frozen; the ground is dry from a period of little or no rainfall; or rainfall intensity is greater than soil infiltration rates.

This paper examines weather events preceding confirmed waterborne disease outbreaks across Canada so that an attempt can be made to identify climate conditions for potential watercourse contamination and therefore increased risk for waterborne disease. Once determined, these climatic indicators can be combined with water system susceptibility (history of waterborne disease outbreaks; inadequate water treatment practices; treatment failures, maintenance and malfunctions) so that vulnerability can be assessed more comprehensively. Given this type of information, water users can increase monitoring, alter treatment practices, issue alerts or, in extremely high risk areas, stop water intake to the plant temporarily in order to protect the population.

1-C-1.4 14:45-15:00

Atlantic Region Meteorological Health Strategy

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Meteorology plays a major role, on a variety of time scales, in the lives of Atlantic Canadians. Increasingly citizens are faced with the reality of dealing with a variety of severe weather and/or environmental events. As well, medical research over the last ten years has increased concerns about the health effects due to various meteorological and atmospheric phenomena. From poor air quality to high temperatures and humidity to lightning awareness, to name just a few, the publics' appetite for accurate and easily accessible educational/awareness information has grown dramatically in recent years. As such, MSC-Atlantic has entered into discussions with the Atlantic provincial departments of health with the objective to design, develop and deliver a multi-stakeholder coordinated approach to the delivery of meteorological, environmental and related health information/program awareness to Atlantic Canadians.

The Atlantic Region Meteorological Health Strategy (ARMHS) is centered on a whole-system approach to tackling the delivery and presentation of meteorological health information and advisories to Atlantic Canadians. Historically the delivery of such information to the public has been accomplished through the mandates of various levels of government and others, each with their own priorities and expertise. While this approach has shown itself to be beneficial to date, as with any program, one continues to strive for improvements resulting in the increased protection to the public-at-large. The ARMHS goes beyond the traditional concept of 'meteorological advisories and health services '. It is about developing an integrated advisory and awareness system in which various stakeholder programs and services are efficiently coordinated resulting in environmental awareness and best health of all citizens.

It is proposed that the ARMHS be designed to meet the threat of current and future meteorological health-related events. Although it is recommended that initial development concentrate on air quality and humidex events, other meteorological phenomena such as summer severe weather, winter storms, wind chill, lightning awareness, hurricanes, storm surge and others be added as the need and resources are identified.

1-C-1.5 15:00-15:15

Weather and Death on Mount Everest: An Analysis of High Impact Storms at Extreme Altitude

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Scientific interest in Mount Everest has been largely focused on the hypoxia caused by the summit's low barometric pressure. Although weather is recognized as a significant risk factor, it has not been extensively studied. Through the use of recent observations made at an elevation of 7,986 m on the mountain's South Col and other datasets, we show that high impact weather events on Mount Everest, including the May 1996 storm in which 8 climbers perished, are often associated with continental-scale intrusions of stratospheric air into the upper-troposphere.

We show that high impact weather on Mount Everest is often the result of convective activity triggered by the variability in the wind speed associated with these intrusions. We provide validation of existing meteorological data that allows insight into barometric pressure variability associated these high altitude storms and their physiological effect on climbers.

1-C-2.1

14:00-14:30
Invited

Impacts of Sea Level Rise and Climate Change on the Coastal Zone of Southeastern New Brunswick

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The objective of this 3-year multi-disciplinary research project is to quantify the impacts of climate change and more specifically sea-level rise, storm surge and coastal erosion on the Gulf of St. Lawrence coastal zone of southeastern New Brunswick, in support of sustainable management, community resilience and the development of adaptation strategies.

LIDAR data are being used to generate a detailed Digital Elevation Model (DEM) of the coast, critical for delineating flooding and inundation zones, natural protection structures such as coastal dunes, and backshore elevation for estimating sediment supply from shore erosion. Meteorological, geological and hydrographical studies will include investigations into measured and forecast sea-level changes due to crustal subsidence and climate change. This project will model the benchmark storm surge events of January 21, 2000 (declared a disaster by the federal government) and October 29, 2000 and develop a “maximum potential” storm surge along this coast given our understanding of historical events. These ranges of storm surge events along with the proposed climate change induced sea level rise scenarios will be placed on the DEM to identify areas along the New Brunswick Gulf of St. Lawrence coast that will be vulnerable to flooding, coastal erosion and inundation over the next 100 years. These impacts will be defined in terms of likely risk with scales of inland penetration of storm surges based on the scenarios presented and their effect on infrastructure, industry and coastal ecosystems.

The coastal zone of south-eastern NB is home to several threatened species of plants and animals. An important aspect of the ecosystem research will be to determine how sea-level rise and future storm events will impact critical habitat and species at risk. Based on existing habitat conditions, the impacts of sea-level rise and storm events on future habitat availability will be predicted. The distribution of keystone species, habitats at risk, and habitat suitability models, will be integrated in order to determine potential impacts on wildlife populations.

Project partners include Environment Canada, Natural Resources Canada, Fisheries and Oceans Canada, Parks Canada, the Province of New Brunswick, Université de Moncton, University of New Brunswick, Mount Allison University, Centre of Geographic Sciences and Dalhousie University, in consultation with municipalities and planning commissions, and with additional financial support from the Government of Canada's Climate Change Impacts and Adaptation Program, and Public Safety and Emergency Preparedness Canada.

1-C-2.2 14:30-14:45

Hindcast of Storm Surges in the Northwest Atlantic, 1960-1999

Natacha B Bernier, *Keith R Thompson*
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There is increasing concern over the possibility of acceleration in the rate of global sea-level rise and its effect on coastal flooding. There is presently a need to identify the regions of Atlantic Canada that are most at risk and project how this risk might change under various climate change scenarios. The simplest approach to estimating flooding risk is based on the extremal analysis of long hourly sea-level records. Unfortunately, there are only two locations in Atlantic Canada (Halifax and Charlottetown) with more than 50 consecutive years of hourly sea level observations. This approach will therefore not provide the required spatial distributions of flooding risk. The alternative approach used here is to base the extremal analysis on the output of a storm surge model driven by long time series of wind and air pressure.

The storm surge model is based on non linear, barotropic dynamics. The model domain extends from 38 to 60 deg North and from 42 to 72 deg West with a horizontal resolution of 1/12 deg. The wind fields required to force the model were provided by Val Swail of Environment Canada. They are specified every six hours for 40 years with a horizontal resolution of 0.625x0.833 deg. The surface pressure fields were inferred from the wind fields using a dynamically-based inversion technique.

Hindcast hourly sea levels from 1960 to 1999 are first compared against observed surges at selected tide gauges. The next step is to combine the surge model output with the predicted tidal elevations to produce hindcasts of total water level at Halifax and Charlottetown. The extremal analysis is then carried out on the annual maxima of observed and hindcast hourly sea levels to test the ability of the model to estimate the return periods of critical water levels. The 40 year output fields of the surge model and a tidal model are then combined to generate spatial maps of return periods of critical levels for Atlantic Canada, and to identify areas most at risk. The final step is to identify trends in the extremes of the last 40 years and explain them in terms of changes in atmospheric conditions.

1-C-2.3 14:45-15:00

Analysis of Historical Water Level Variations, Storm Surges and Return Periods for the Estuary and Gulf of St. Lawrence

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Historical tidal gauge data from the St. Lawrence estuary and gulf, together with the atmospheric pressures and wind stresses, are analysed for understandings of the water level variations patterns, recognitions of the storm surges and predictions of their return periods. Three types of long term annual mean sea level variations are identified: oscillation type, linear increase type and linear decrease type. Strong climatologic seasonality in the non-tidal induced (residual) water level variations are found to be linked mainly with the seasonality in the atmospheric pressures.

Extreme value statistical analyses are performed for the storm surges and their return periods for the sites where century long time series are available. Also performed are the regression analyses of the residual water levels against the air pressure and winds, and of the long time series water level variations against short ones at different sites.

1-C-2.4 15:00-15:15

Climate Change Impacts on Beaufort Sea Shoreline

Gavin K Manson[1], *Steven M Solomon*[1], *Adam W MacDonald*[2]
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Retreat of the Beaufort Sea coast is driven by relative sea-level (RSL) rise coupled with wave and storm surge impacts which can cause up to several metres retreat of partially thawed, unconsolidated cliffs during a single storm in the June to October open water season. The signatures of climate change in the region are anticipated to include accelerated sea-level rise, decreased sea ice extent, and increased temperatures. Mean storm intensities and annual frequencies are anticipated to remain constant, but storms will occur over a longer open water season, with higher water levels associated with wave action higher on the shoreface and flooding further inland. Cliffs may also be more susceptible to erosion by virtue of warming air temperatures and increased active layer thickness.

Analyses of historical records of winds, water levels, sea ice and air temperatures from the region indicate that open water season stormy periods occurred in the early 1960s and the mid-1980s. Sea ice extent is variable in the open water season with approximately five year periodicity between heavy and light years and an apparent trend towards a longer open water season reflected in a similar apparent warming trend in air temperature. At Tuktoyaktuk, northwesterly open water season wind events are not well correlated with high water level events as water levels are influenced by additional factors other than local winds. In multiple regression, peak storm wind speeds and directions were found to explain 66% of variability in peak storm water levels though open water extent did not significantly contribute.

Calculations of return periods using the Generalised Pareto Distribution and Peaks-Over-Threshold method indicate a 25 year return period for wind speeds of 96 km/h and water levels of 2.3 m chart datum. Return periods were also calculated for 2050 and 2100 assuming storms occurring over a lengthening open water season with no change in frequency or intensity, and water levels elevated according to predicted RSL rise. The 25 year wind speed is expected to increase only slightly by 2100 though the 25 year extreme water level is expected to increase to 3.2 m. CGCM results indicate increasing temperatures and the Beaufort Sea ice climate becoming similar to the present day Gulf of St. Lawrence. This scenario of climate change will have strong impacts on shorelines of the Beaufort Sea, bringing more severe flooding and accelerated coastal change.

1-C-2.5 15:15-15:30

Historical and Possible Future Changes of Wave Heights in Northern Hemisphere Oceans

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In this study, we review and extend previous studies on changes of wave heights, focusing on both observed and possible future changes in the North Atlantic and in the North Pacific. Two wave hindcasts are used here as observed waves for 1958-1997: a global wave hindcast based on the 10-m winds taken from the NRA (i.e., the reanalysis of the NCEP/NCAR), and a detailed North Atlantic wave hindcast produced with intensively reanalyzed surface winds over the North Atlantic basin. The observed relationships between sea level pressure (SLP) and significant wave height (SWH) are used to construct climate change scenarios of SWH: Scenarios of seasonal mean SWH are constructed by means of redundancy analysis (RA), while projections of seasonal extreme SWH are made using non-stationary generalized extreme value (GEV) models. The RA and GEV models are trained using the NRA SLP and the observed SWH data for 1958-1997. The SWH scenarios are constructed using seasonal mean SLP and squared SLP gradient fields from a coupled climate model (CGCM2) under three different forcing scenarios. The projected (and observed) trends/changes in SWH are assessed by conducting a trend analysis, in which linear trends are evaluated against quadratic trends.

Both oceans had significant changes in both winter and fall seasonal extremes (and means) of SWH during 1958-1997; they are also projected to have significant changes in the 21st century under all three forcing scenarios. The rate and sign of the projected future SWH changes are not constant throughout the 21st century; and in some regions, these appear to be quite dependant on the forcing conditions. Often, the projected SWH changes are characterized either by faster increases in the late decades than in the early decades, or by decreases in the early decades followed by increases, depending on the forcing scenario and the specific location. The rate of SWH change appears to have a positive relationship with the rate of increase in the greenhouse gases forcing. Changes in ocean wave heights are associated with changes in storm tracks and cyclone activities over the oceans. In the projected warmer climate, the North Pacific storm track rotates clock-wise in winter (JFM), with more frequent occurrence of strong cyclones in the southeast and northwest of the North Pacific; while the storm track over the northeast Atlantic slightly rotates clock-wise in fall (OND), with more frequent occurrence of strong cyclones in northern Europe and over the Norwegian Sea.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00

**complete abstracts cited under Poster Session, pp. 167-178*

P-2 (1-C-2)

Seasonal Comparisons of Strong Western North Pacific Cyclones and the SST Anomalies Beneath Them.

Richard E Danielson[1], *John R Gyakum*[2] ([1]Department of Oceanography, Dalhousie University, Halifax, NS, Canada; [2]Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, QC, Canada)

P-3 (1-C-2)

High-Resolution Marine Wind Retrieval using Synthetic Aperture Radar. ***Richard E Danielson***, *Harold Ritchie, Michael Dowd* (Dalhousie University, Halifax, NS, Canada)

1-C-3.1 14:00-14:15

Atmospheric Monitoring Network Data Quality Assurance Requirements and Approaches

Richard Campbell
Atmospheric Science and Water Survey Directorate (AMWSD), Meteorological Service of Canada (MSC), Downsview, ON, Canada
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Automated software tools are vital for a good atmospheric data quality control (QC) program. However, even the most carefully designed algorithms will miss some erroneous observations. In some cases, valid meteorological phenomena result in false failures of automated tests. Manual Quality Assurance (QA) techniques in near real-time complement automated QC tools. MSC's atmospheric monitoring network managers have identified the need for this level of human intervention into the QA/QC process. This need is consistent with that of their US counterparts for networks such as the US Climate Reference Network and the Oklahoma Mesonet.

MSC's National Monitoring Desk (NMD) was originally established in 1996 to meet NAV CANADA's QA needs for the aviation network. The highest priority of the NMD staff is to fulfill its obligations under the NAV CANADA contract. The NMD also acts a point of contact to report and/or follow-up on performance problems from other networks. However, lack of adequate software tools has precluded the NMD from providing any significant proactive QA support to those networks.

The requirement for near real-time network QA for the non-aviation networks is somewhat similar to the contracted services being provided to NAV CANADA. The NAV CANADA contract has provided a basic infrastructure for monitoring and A-Base networks could build on this infrastructure, incrementally. NAV CANADA has provided EC with the salaries for a core set of personnel along with hardware, software and procedures to meet NAV CANADA's requirements. By adding a mix of people power and tools, EC would be able to meet its A-base monitoring requirements very economically and without compromising the contract obligations. Therefore automated QA tools are being developed to assist the NMD in the areas of monitoring, flagging, trouble tickets, user notification and network performance reporting. The initial implementation phase expected in 2004-2005 will allow the NMD to improve QA services for the surface non-aviation networks. Future expansion of NMD's QA services for other networks will also be considered.

1-C-3.2 14:15-14:30

Calculation of the 1971 to 2000 Climate Normals for Canada

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"Normals" is the term commonly used for values of climatic elements averaged over a fixed, standard period of years. The last standard international period set by the World Meteorological Organization (WMO) was 1961 to 1990. However the WMO recommends that countries should update their Normals every decade, using a 30-year period. In this vein, the Meteorological Service of Canada (MSC) prepared the Canadian Climate Normals for the period 1971 to 2000.

This paper describes the calculation methods used to develop the Normals. It includes a discussion of the MSC network and observational changes that occurred and the impacts on which stations and observational elements and summary information such as extremes were included. Normals were calculated for many locations for which complete data were not available for the 30-year period. A discussion is included on the impact on the use of fewer than 30-years to calculate averages to represent the Normals period. Finally, the publication of the Normals on the MSC web site is presented.

1-C-3.3 14:30-14:45
Access to Historical Weather and Climate Data from the MSC
Robert J Morris
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The Meteorological Service of Canada (MSC) introduced basic, interactive public access to selected historical weather and climate data in 2003 on its "weatheroffice" internet site. This presentation will outline the objectives and the development of this site, the characteristics of the data and the use of the various features of the Internet site.

The paper will also describe continuing efforts to improve the site. These include adapting to the modernization of the MSC's monitoring networks and data management practices. Other challenges remain. One of the areas of important potential is access to larger amounts of historical data for specialized uses. This includes research, climate change and historical drought studies; and extreme value analysis of ice, wind and snow loads, and precipitation events for structural design. The presentation will outline some of the issues and options with respect to formats, file sizes and metadata and our current plans for developing improved access.

1-C-3.4 14:45-15:00
Modernization of the National Climate Hardcopy Archives in Downsview (CHAD)
Anna Deptuch-Stapf
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Climate Hardcopy Archives in Downsview (CHAD) consists of the wealth of mostly Canadian historical climate data and metadata in many different formats, such as: original paper documents, microfilms, historical data loggers, satellite images, or historical weather maps. There is a big effort underway to modernize CHAD in order to inventory its content as ell as to provide easy access to all its data. This paper will list type of data and metadata which are stored in the CHAD as well as Web access tools.

1-C-3.5 15:00-15:15

COOLTAP – Real-Time Distribution of MSC T&P Climate Data

***John MacPhee**, Ryan Heffron*
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The Meteorological Service of Canada is modernizing the reporting infrastructure for its Temperature and Precipitation (T&P) Climate Observer Network, the largest of its monitoring networks. The T&P Network is comprised of stations situated on privately owned land from which volunteer observers gather Maximum and Minimum temperature data, as well as rainfall, snowfall, snow-depth data, twice daily. The observer logs these data on a paper form which is sent to MSC regional offices at month end. It can take up to 18 months for the MSC to manually Quality Control (QC), keyboard, and archive these data to make them available for distribution.

Electronic reporting through COOLTAP, a web-based software application, is a critical improvement needed to modernize the T&P Network reporting methodology and Quality Control infrastructure. The Atmospheric Monitoring and Water Survey Directorate (AMWSD) is converting the T&P Network to near real-time reporting in response to a sharp increase in new applications which require T&P Network data, in a near real-time format. COOLTAP will eliminate the paper processing as it allows the observer to enter the data, through any internet-connected computer, directly onto an MSC server which will provide automated data Quality Control and immediate observer feedback. COOLTAP electronic reporting will improve the availability of the climate observations from several months for paper based processing, to “next day in the archive”.

This presentation will include a detailed view of: the present T&P Network, the network as we envision it by March, 2006, as well as an introduction to the COOTAP software which will make this transition possible.

1-C-4.1

14:00-14:15

A High Resolution Full-Scale 3D Model of Glaze Ice Accretion on a Non-Energized Station Post Insulator

Wladyslaw J Rudzinski[1], *Edward P Lozowski*[1], *Masoud Farzaneh*[2]
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Understanding ice build-up on large objects of complex geometry is essential when using power network equipment in cold regions. Glaze ice accretion with numerous icicles is the most severe type of ice accretion, particularly for outdoor insulators, since it considerably reduces their performance. When icicles bridge insulator sheds, conductive liquid flows along the ice surface, causing electrical discharges and flashover, which may result in power failure. In order to reduce flashover occurrences, it is important to understand and be able to simulate glaze ice formation. Our research focuses on the most promising theoretical approach to this problem, namely stochasting modelling of glaze ice accretion on outdoor insulators. In the present paper, we describe a novel, high- resolution, full-scale 3D discrete particle model of glaze ice accretion on a non-energized station post insulator. In this model, which we call a morphogenetic model, Monte Carlo methods are used to emulate the mobility of fluid particles, leading to their random walk over the ice accretion surface. The model is able to predict the detailed distribution of ice mass over the structure under a range of glaze icing conditions.

In the present paper, 3D model simulations of ice accretion morphology on a full-scale insulator are examined as a function of the microscopic model parameters, specifically the freezing probability, the shedding parameter, the wind stress parameter, and the total precipitation. An important advantage of our morphogenetic model over traditional continuous models is its ability to emulate icicle formation. In the future, model predictions will be validated using results from laboratory experiments undertaken in the Precipitation Icing Simulation Laboratory at CIGELE at the University of Québec in Chicoutimi. These laboratory experiments were undertaken using a full-scale, 3D station post insulator over a range of simulated air temperature, wind speed and precipitation rate. In order to make the model useful, we will also derive relations between the model parameters and the controlling atmospheric conditions.

1-C-4.2

14:15-14:30

A Portable Calorimeter for Measuring Liquid Fraction in Spongy Freshwater Ice Accretion

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Atmospheric ice accretion often occurs with the incorporation of unfrozen liquid into the ice structure. This type of accretion is said to be spongy and is known to occur in hailstone growth, in marine icing, and in aircraft icing. It is suspected that it may also occur, in the icing of electrical power network equipment during freezing rain. The degree of accretion sponginess has important implications for the resulting ice loads and for the modelling of those loads. Hence, accurate experimental measurement of the proportions of ice and water in a spongy ice accretion is essential for design purposes.

A calorimeter has been developed for determining the liquid fraction in freshwater ice accretions, by melting a sample in warm water. The components of the calorimeter system are inexpensive and easily fabricated and the system is portable for field work. The calorimeter is operated as follows. An ice accretion sample, in the range of 5 to 55 g, is placed in warm water inside the calorimeter and the resulting temperature change is measured to the nearest tenth of a degree Celsius. A heat balance equation is formulated expressing the conservation of thermal energy. The heat balance includes a term that describes unaccounted for heat gains and losses and errors in the defined terms. The error term has been determined empirically and given a statistical description from a set of controlled experiments. For a calorimeter run, the error term is estimated from known quantities and the proportion of ice and liquid can then be determined from the heat balance. The method has been validated using a set of independent data with known ice fraction. Our method is designed for ice samples with a range in mass of 5 to 55 g. Over this range, the absolute uncertainty in liquid fraction (or ice fraction) varies from ±0.033 for 5 g samples to ±0.0092 for 55 g samples. For most purposes, an uncertainty in liquid fraction of ±0.033 would be quite acceptable and it appears that the present calorimeter is a suitable instrument for measuring the liquid fraction of spongy ice.

1-C-4.3 14:30-14:45

Systematic Experiments on Ice Spike Growth in a Cold Room

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Ice spike observations in nature have sparked much interest in the scientific and non-scientific communities alike, yet most research performed thus far has been largely of a qualitative nature. A systematic investigation was necessary to properly evaluate theories explaining ice spike growth and conditions conducive to growth. Through experimentation with two water types in different containers, basic conditions for the development of ice spikes were satisfied and ice spike growth was observed. Growth was captured using digital photography that was later analyzed for determining the growth rate of the ice spikes. Water temperature was observed throughout the freezing process and was used to derive a growth rate equation. We show the frequency of ice spike formation under specific growth conditions and explore the thermodynamics influencing ice spike development.

1-C-4.4 14:45-15:00

Detection of In-Flight Icing Conditions through the Analysis of Hydrometeors with a Vertically Pointing Radar

Jennifer Lilly, *Frédéric Fabry*
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According to the Air Line Pilots Association, 97% of icing accidents take place during the approach, landing, holding, or go-around phase of flight. For this reason, identifying hydrometeors, especially the supercooled liquid water (SLW) that causes icing, in a vertical column above the airport is a crucial step in reducing the number of icing accidents. Armed with information about the type and location of any precipitation, pilots, meteorologists, and air traffic

controllers can safely route airplanes away from danger. In this study, we aim to provide a now-cast of icing condition in the vicinity of an airport using a Vertically Pointing Radar (VPR).

The VPR is an X-band Doppler radar, developed at McGill University, which measures reflectivity, Doppler velocity, and the distribution of hydrometeor fall speeds. With these variables, collected at 10-minute averages in the horizontal and 75 m resolution in the vertical, a computer can be programmed to identify the melting layer, types of precipitation, and location of precipitation. Further analysis of the data provides information about potentially dangerous icing regions. From the distribution of fall speeds, one can separate out modes, or peaks in the power returned, and the existence of more than one mode is a good indication of a hidden type of hydrometeors, such as SLW. In addition, a relationship between reflectivity and Doppler velocity provides information on the type of hydrometeor and warns of conditions like riming, an excellent indication that there is SLW in the region.

When combined into one system and run continuously over time, the 5 algorithms in this study will be able to provide a timely, affordable, and valuable warming as to the level and extent of icing conditions occurring in the airport region. When considering the value of the information provided by the VPR, it is important to note that it costs only a tiny fraction of typical scanning radar.

1-C-4.5 15:00-15:15

Aircraft Icing Environments in Mixed Phase Clouds

Stewart G Cober, *George A Isaac*
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Aircraft icing environments observed in mixed phase cloud conditions are characterized and compared to similar characterizations for liquid phase clouds. The data were obtained from 95 research flights conducted during five field projects. The cloud environments were averaged over horizontal extents of 3 km and were assessed in terms of liquid, ice and total water contents, and the average droplet and ice crystal spectra. The icing environments were assessed in terms of liquid water content (LWC) and droplet median volume diameter (MVD) and temperature.

Overall, mixed phase cloud conditions were observed for 44% of the in-cloud observations. The total water content of liquid and mixed phase icing environments were quite similar, with 50% and 95% values of approximately 0.13 and 0.36 g m-3 respectively. Conversely, it was found that mixed phase conditions were considerably less likely to have extreme LWC and/or extreme MVD values. It is suggested that the co-existence of large drops (> 100 microns) and ice crystals could rapidly lead to glaciation of these drops through collision and ice multiplication processes. The co-existence of high LWC and ice crystals would lead to rapid growth of the ice crystals through riming, which would reduce the total LWC. Implications for detecting and forecasting mixed phase icing environments will be discussed.

1-C-5.1 14:00-14:15

The Tornadoes in Ontario Project (TOP)

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The Tornadoes in Ontario Project (TOP) was undertaken to improve the Meteorological Service of Canada tornado database for Ontario. There are three areas where work is focused:

1) improving the quality of data coming into the database,
2) updating the database to the current year, and
3) revising past events using the latest scientific knowledge.

Work to date has included better follow-up on reports from the public and a greater emphasis on damage surveys. In addition, a decision tree was developed to help classify tornadoes as 'possible', 'probable' or 'confirmed' and a new tool to assist with assigning Fujita scale values was created. Tornado events from 1993 to 2003 have been completed and results from this period will be presented at the meeting.

1-C-5.2 14:15-14:30

A Case Study of Three Severe Tornadic Storms in Alberta

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Central Alberta is highly susceptible to severe thunderstorms which spawn tornadoes. There are about 10 tornadoes reported each summer, most of which are of F0-F1 intensity on the Fujita scale. During the past 20 years there have been three tornadic thunderstorms in central Alberta with intensities of F3 or greater. These events were: the Edmonton tornado of 31 July 1987 (27 deaths and 250 million dollars of property damage), the Holden tornado of 29 July 1993, and the Pine Lake tornado of 14 July 2000 (12 fatalities, more than 130 injuries and over 13 million dollars damage).

A synoptic analysis of these three cases was made to examine the validity of the Smith and Yau conceptual model of severe thunderstorm outbreaks in central Alberta. In each case a capping inversion allowed the build up potential instability resulting in large values of convective available potential energy. Also these storms had strong wind shear and large precipitable water. The storms differed in the triggering mechanism to break the cap and also in temperature advection. For the Pine Lake storm there was mid-upper level cooling whereas, for the Edmonton and Holden cases there was low level warming but little or no mid-upper level cooling. The Pine Lake and Holden storms had straight tracks, while the Edmonton storm made an abrupt change in direction and speed. Thus, extrapolation of tornadic thunderstorm movement would not be a viable nowcasting technique in this case.

1-C-5.3 14:30-14:45

The Edmonton Severe Thunderstorm of 7 August 2003

B Kochtubajda[1], *DR Hudak*[2], *DML Sills*[2], *S Boodoo*[2], *M Lapalme*[1]
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A short-duration, severe thunderstorm rumbled through the city of Edmonton in the late hours of August 7, 2003. The 62.4 mm rainfall at the Municipal Airport was the 4th wettest August event since 1888. The northeast part of Edmonton was hardest hit. A unique dataset was collected including radar data from the Carvel Doppler weather radar facility, lightning data from the Canadian Lightning Detection Network (CLDN), power outage data from EPCOR, surface measurements from a rain gauge network operated by the City of Edmonton Drainage Service Department, and upper-air and surface data from the Environment Canada networks.

Between 11:15 PM MDT Aug 7 and 12:20 AM MDT Aug 8, the rain gauges at the Municipal and Namao airports received 55 mm and 57 mm, respectively. The CLDN detected nearly 600 lightning strikes within 20 km of the Municipal airport in the same time period. Over 25,000 Edmontonians were affected by the power outages. Part of Edmonton's Light Rail Transit (LRT) was flooded and shutdown the following day affecting about 34,000 commuters. Data provided by the Drainage Service Department revealed that the maximum 5-min rainfall intensity was 117.6 mm/hr and the maximum return period was estimated to be 1 in 200 years near the Municipal Airport. The peak flow at the Rat Creek overflow station was estimated at 26.2 cm. Radar cell properties deduced from the Canadian Radar Decision Support System were related to the observed lightning and rainfall characteristics of the storm. A number of boundary layer convergence lines were detected by the Doppler radar, and their interactions played a significant role in the enhancement of the storm and associated lightning.

1-C-5.4 14:45-15:00

Severe Weather Outbreak South-Central Alberta on 11 August 2003

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Over $10 million in hail damage was reported over south-central Alberta as a result of the severe weather outbreak of 11 August 2003. One storm also produced a tornado west of Coronation. In the mid afternoon, several severe and long-lived thunderstorms developed along the Rocky Mountain foothills and travelled north-eastwards through south-central Alberta.

Analysis of reflectivity data from the Weather Modification Inc. radar (51.7º N, 114.1º W) indicated that at least three of the storms lasted over three hours and produced storm tracks over 200 km in length. Two zones of preferred severe thunderstorm activity were identified within the radar domain. Analysis of proximity sounding data revealed that the antecedent atmospheric conditions over south-central Alberta were suitable for the development of low-precipitation supercells. Yet within this environment, several storms exhibited classic and high-precipitation supercell characteristics.

We investigated possible factors that may have resulted in this wide range of thunderstorm intensity over such a confined area. This included examining the potential to increase the precipitation efficiency through natural seeding of downwind storms by the influx of hydrometeors originating from the anvils of upwind storms. The storms' intensities were also affected by the availability of low-level moisture, while the location of initial storm development was found to be influenced by the distribution of morning cloud cover.

1-C-5.5 15:00-15:15

Exploratory Analysis of the Effect of Hail Suppression Operations on Precipitation in Alberta

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An operational hail suppression program has been based in southern Alberta, Canada since 1996. The program is designed to reduce hail damage to property in towns and cities. The analysis of the effect of the cloud-seeding on the rainfall was motivated by concerns that hail suppression operations might reduce rainfall, and thus offset any economic gain offered by a reduction of hail damage.

An exploratory analysis of volume-scan, C-band radar data using sophisticated storm cell tracking software was used to calculate radar-derived rainfall characteristics from 160 seeded and 1167 non-seeded storms, on 82 days with seeding, during the summers of 2001 and 2002. The seeded storms (stratified according to maximum radar-derived cell top height), have greater mean durations (+50%), have greater mean precipitation rates (+29%), and have a greater mean total rain Area-Time-Integral (+54%). There is statistical evidence to reject the null hypothesis of no effect of cloud seeding on the total volume of rainfall. The data support the claim that seeding causes an increase in rainfall. The seeding effect is estimated to increase the mean rainfall volume (averaged for categories 7.5 km to 11.5 km height storms) by a factor of 2.2, with an average 95% confidence interval of (1.4, 3.4).

1-C-5.6 15:30-15:45

The Alberta Hail Suppression Program: A Program Designed to Mitigate Urban Hail Damage in the Province of Alberta, Canada

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Insurance claims due to hailstorms in urban area have escalated over the past 10 years. Denver Colorado was pounded by golf-ball to tennis-ball sized hail on July 11, 1990 and damages reached a record (for the USA at that time) $625 million. In Canada, the damages associated with a severe hailstorm that struck Calgary on September 7, 1991 were estimated at $400 million (Charlton et al., 1995). Insured claims from the hailstorm that struck Sydney Australia on April 14, 1999, were approximately $1.5 billion, making it the most damaging event in Australian insurance history.
A study by Herzog (2002) compiled and summarized the hailstorm damages in the USA for the

period 1994-2000 for the Institute for Business and Home Safety (IBHS). Verified hail losses amounted to $2.5 Billion per year, with the actual amount possibly being 50% higher. Personal building losses totalled $11.5 Billion (66%), commercial building losses totalled $2.7B (15%), and vehicles accounted for $3.3B (19%). And most recently, the most damaging hailstorm ever recorded in the USA moved from eastern Kansas to southern Illinois on 10 April 2001, depositing 2.5- to 7.5-cm-diameter hailstones along a 585-km path, over portions of the St. Louis and Kansas City urban areas collectively created $1.9 billion in damage claims from a 2-day period, becoming the ninth most costly weather catastrophe in the United States since property insurance records began in 1949 (Changnon and Burroughs, 2003).

The new Alberta Hail Suppression Project was initiated in 1996 as a result of the increased frequency of damaging hailstorms in Alberta, compounded by an increasing population inside an area of high storm frequency. It is the first project of its kind in the World to be entirely funded by private insurance companies with the sole objective of reducing the damage to property by hail. The project was made an ongoing program of the Alberta insurance industry in 2001 because of the drop in hail insurance costs in Alberta, counter to the trend in the rest of the country and the World.

This paper/presentation reviews recent trends in insurance damage claims (property, auto, crop) highlighting changes since the hail suppression program began. Radar measures of seeded and natural storms will also be discussed.

1-D-1.1 16:00-16:15

Arctic Catastrophes: Rapid Sea Ice Changes in the Canadian Arctic and the Impact on Humans

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Climate warming and reduction of sea ice during the last 3 decades appears to be forcing catastrophic changes on the Inuit people of the Eastern Canadian Arctic. Large breaks in the archaeological records also suggest that past climate changes caused abrupt abandonment of settlements and life style shifts in Paleo- and Neo-Eskimo societies. The centennial-scale resolution of the archaeological records and previous paleoclimatic reconstructions, however, does not permit detailed examination of this idea. We therefore examine the decadal-scale paleoclimatic changes recorded by quantitative palynological data in a continuous 6,500 year record from Coburg Polynya (75°35'N, 78°41'W) near Paleo- and Neo-Eskimo sites on the North Devon Lowlands and in 2 cores from the North Water Polynya (NOW) between Ellesmere Island and Thule, Greenland (77°16.0'N, 74°19.9'W). Paleotransfer function data from dinoflagellate cyst assemblages provide quantitative estimates of changes in sea surface temperature (SST) and sea ice cover (SIC) with the same accuracy as historical shipboard oceanographic measurements. Both sites record abrupt temperature changes of 2-4°C that can be related to the archaeological record of major changes in hunting modes of Paleo- and Neo-Eskimo peoples and to occupation-abandonment cycles on Devon and Ellesmere Islands. The paleoceanographic reconstructions show that from ~6500 to 2600 BP, there were large oscillations in summer SST from 2-4°C cooler than now to 6°C warmer, and annual variations in SIC ranged from 2 months more of heavy (>50%) ice to 4-month extensions of open water. This interval corresponds to the period of pre-Dorset Palaeo-Eskimo cultures that hunted musk ox and caribou. The subsequent marine-based Dorset and Neo-Eskimo cultures correspond to progressively cooler intervals with expanded sea ice cover. Our records show that in the past, the warming took ~50-100 years and lasted about 300 years before being replaced by colder intervals of ~200-500 years. These climate oscillations are more rapid than the major cultural changes in the archaeological record, but are of similar length to successive Palaeo-Eskimo occupations in the NOW region of Nares Strait.

1-D-1.2 16:15-16:30

Linking Climate Variability and Community Outcomes through Historical Newspaper Analysis of Extreme Weather and Disaster Events

Karen McDonald[1], *Justine DA Klaver*[2], *J Peter Rothe*[2], *Karen E Smoyer-Tomic*[2], *Colin L Soskolne*[2], *Donald W Spady*[2]
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With changing climate, the frequency, severity and unpredictability of extreme weather events and disasters are expected to rise. For future planning, the question of how Albertans coped in the past under conditions of extreme weather is being addressed through a novel approach to combining weather data records and newspaper archives. Daily meteorological and disaster databases were employed to identify extreme weather events in Alberta. An analysis of the weather records over

several decades was first performed to identify any trends in variability of weather extremes using five key stations with substantial periods of record covering the province from north to south through most ecosystems. Linkages between environmental conditions are made to determine the potential combinations of events that are most significant.

Newspapers are an underutilized source of epidemiological information. They can provide the context surrounding an event, and describe how the event and outcomes were actually experienced by people locally. They thus can be useful both quantitatively and qualitatively. Based on the time of the weather events, the archives were searched for articles relating to the weather phenomenon. The number and content of the articles gives some indication of the relative importance and response made by communities to the extreme conditions.

The historical impact on health in Alberta associated with disasters and extreme weather is investigated using print media accounts of the local community's experience of selected events. The application of this novel epidemiological method will provide a research tool that could aid in understanding how changing ecological conditions can affect not only social conditions, but also the subsequent health of communities.

1-D-1.3 16:30-16:45

The Road Well Travelled: Implications of a Future Climate on the Performance of Pavement Infrastructure in Southern Canada

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Relatively little research has been conducted linking climate change to the future state of Canadian road and pavement infrastructure—despite the substantial $100 billion asset value of the road system, the dependence of Canadian economic and social activity on road transport, and the documented influence of climate and other environmental factors on the deterioration of pavements. In response to this knowledge gap, the authors have developed a research project that targets three climate-related issues that are likely to affect flexible pavement performance and management in southern Canada (regions not underlain by continuous or discontinuous permafrost) over the next several decades:

1. Permanent deformation associated with heat-related rutting;
2. Thermal cracking associated with low temperatures; and
3. Frost heave and associated seasonal deformation stress.

Implicit in each of these issues are the interactions among climatic conditions, traffic volume/mix, and construction (e.g., design standards, materials) and maintenance variables. The presentation will summarize results from the literature review component of the project and describe longer-term goals and objectives.

1-D-1.4 16:45-17:00

Science for Ontario Municipalities' Emergency Management Planning: the Atmospheric Hazards in Ontario Website

Joan Klaassen, *Heather Auld, Neil Comer, Bryan Tugwood, Don MacIver*
Meteorological Service of Canada (MSC), Ontario Region, Downsview, ON, Canada
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Ontario's new Emergency Management Act (2003) requires all municipalities and provincial ministries to develop and implement comprehensive risk-based emergency management programs. To assist Ontario municipalities in planning for environmental risks and emergencies, the Meteorological Service of Canada (MSC), in partnership with Emergency Management Ontario, has developed a prototype 'Atmospheric Hazards in Ontario' website.

The website provides users with an extensive collection of maps, data and documentation for a variety of meteorological and health related hazards for Ontario. These include extreme heat and cold, drought, extreme rainfall, fog, hail, heavy snow, lightning, hurricanes, ice storms, tornadoes, wind storms, smog, UV radiation and acid rain. The presentation will focus on the objectives of the website and how the information can be used by municipalities to identify their risks from atmospheric hazards.

1-D-1.5 17:00-17:15

Collisions, Causalities, and Costs: Weathering the Elements on Canadian Roads

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Contact: Brian.Mills@ec.gc.ca

The tremendous mobility afforded by the road system is offset in part by the health and economic burden of motor vehicle collisions (MVCs). MVCs annually drain about $CDN10 billion from the Canadian healthcare system. Weather is an important environmental factor that has been studied and associated with increased MVC and injury risk. However, more research is needed to understand how collision risk varies for different types of meteorological conditions and driving contexts. Few researchers have examined the economic costs of weather-related collisions even though significant resources are used to reduce road weather hazards, such as the $CDN1 billion spent by Canadian agencies each year on winter maintenance. This presentation reviews research conducted by the authors over the past two years to develop a national weather-related collision risk profile and to assess the costs of weather-related road collisions in Canada.

1-D-2.1 16:00-16:30 Invited

Course and Fine Resolution Modelling of the North Atlantic Thermohaline Circulation

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The characteristics and variations of the thermohaline circulation (THC) in the North Atlantic are described using a suite of coarse to eddy-resolving basin-wide models (the Kiel-FLAME models). Mechanism of interannual to interdecadal variability in the THC driven by surface forcing are described for a coarse resolution model version. Essentially the same features can be found in eddy--permitting/resolving versions of the model, suggesting only a weak impact of meso-scale processes on the large scale circulation changes in the North Atlantic. However, we show a potentially important role of meso-scale processes for the signal propagation related to THC changes, leading to a much faster dynamical time scales compared to a model neglecting meso-scale processes. A second, maybe more important meso-scale control on THC changes is given by the role of eddies for mixing between boundary currents and the interior of the Labrador Sea, the restratification after deep convection and related watermass characteristics of newly formed Labrador Sea Water. Eddy-resolving experiments show that this process might be able to counteract the atmospherically driven variability in convection activity and related THC changes.

1-D-2.2 16:30-17:00 Invited

Project Argo – Current Status and Expectations

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Argo is now well on its way to operational status. As the time I start to write this abstract there are a total of 1090 profiling floats operating in the global ocean deployed by 18 nations. By the time I finish the abstract there will likely be more floats in the ocean. Presently under way is a large effort to complete the deployment of floats in the Pacific sector of the Southern Ocean. The Argo Program Director has computed that when Argo is fully implemented it will gather more oceanographic data in the southern ocean in one year than has been gathered by all previous research missions to the southern ocean. This talk will provide an overview of the current status of the Argo array and the current status of the Argo data system. Some changes have taken place very recently in the data system and it should be clear by the time of the Congress whether or not these changes were useful. The Argo community is aiming to have all data available without any limitations on access in near real-time. We are close, a recent estimate suggests that 90% of all profiles are available on-line within 24 hours of acquisition. Besides outlining the present status of the Argo array I will also present an outline of deployment plans over the next 6-12 months and try to describe what the array will look like one year from now.

1-D-2.3 17:00-17:15

Quantifying Measurement Errors in ERS and ENVISAT Satellite Altimetry

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Determining measurement errors in satellite altimetry is an ongoing process, becoming more important with the growing use of data assimilating ocean models, which require estimates of the

error covariance matrix. An important aspect of the error covariance matrix is accurately determining the spatial dependence of the measurement errors, which are estimated from crossover differences in the sea surface height (SSH). Crossing time differences vary between +/- 17.5 days, the shortest time difference being 0.5 day, allowing for an extrapolation of the standard error to the zero crossing time where the height discrepancy is solely due to errors in SSH. This can be done regionally for a greater understanding of the spatial structure of the measurement errors. All analyses are done for the Pacific Ocean to be incorporated into future data assimilation projects.

1-D-2.4 17:15-17:30

Coupled regional climate simulation in the Gulf of St. Lawrence, Eastern 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. Three relatively large inner basins: the Gulf of St-Lawrence (GSL), the Hudson Bay/Hudson Strait/Foxe Basin system and the Great Lakes, are also influencing the evolution of weather systems and therefore the regional climate. Research efforts are being made in Canada to developed a coupled regional climate modelling system that represent the climate of Eastern Canada, linking the Canadian Regional Climate Model (CRCM) developed at the "Université du Québec à Montréal" (Caya and Laprise 1999) with different oceanic components to study past, present and future climate of our area.

In this study, a multi year simulation has been done over Eastern Canada with the CRCM coupled with an ocean-ice model for the Gulf of St. Lawrence (GOM) developed at the "Institut Maurice-Lamontagne"(Saucier et al. 2003). The simulation was performed over 5 years from December 1st, 1989 to November 30th, 1994 to reproduce the observed atmospheric and oceanic conditions. This experiment is a follow-up to a 5-month sensitivity study previously done with the CRCM and GOM (Faucher et al., 2004) to verify the ability of the coupled system to reproduce the known characteristics of the regional circulation such as mesoscale oceanic and atmospheric features, fronts and sea-ice over several seasons and years. The results of the coupled simulation are compared with the results of an uncoupled simulation performed over the same period where ocean conditions are prescribed from observations, and they are validated with observations from different databases.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00

**complete abstracts cited under Poster Session, pp. 167-178*

P-4 (1-D-2)
Initialization of a Pacific Ocean Data Assimilation Project. ***Mark P Cheeseman***, *Tsuyoshi Wakamatsu* (Institute of Ocean Sciences, Sidney, BC, Canada)

1-D-3.1 16:00-16:30 Invited

Forecasting Polar Lows in the Norwegian and Barents Sea

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Polar Lows are fairly intense convective meso scale vortexes, in the Atlantic mostly found north of 65 degrees N. The polar low is uniquely associated with cold air outbreaks, and gives rise to sudden changes in weather, gale force winds, and heavy precipitation. Some cases hit the coastal areas of Northern Norway, and are then forecast at the Norwegian Meteorological Institute in Tromsø (VNN).

The polar low is challenging to forecast due to its small horizontal scale and short duration, and because of the scarcity of observations. The best tools for detection are AVHRR imagery, and satellite surface winds. Up till recently, the models could only partially resolve the polar low and usually quite erratic. This has improved somewhat with the introduction of the 10 km and 20 km resolution model, but there is still a need for substantial correction and interpretation from the forecaster. Because of the low number of cases each year, forecasters are often unprepared, or, lack the experience in forecasting the polar low.

A work group was formed in 1999 with the goal to improve the skill of the forecaster, to find a common methodology of forecasting, and to gather data and facts. A graphic chart was introduced, in a work efficient format, to be issued to designated aviation users. In forecasting polar lows, some aspects are simple and well understood. Initial conditions, like the low level cold air outbreak and the cold trough aloft must be present. Finding propagation speed and direction is a more delicate task, as is the question of intensification and dissipation. Effects like CISK, WISHE, and CAPE are important in maintaining strength, but the explicit diagnostication of these is difficult in operational forecasting. Favourable conditions can be inferred from AVHRR imagery however. Some guidelines has been implemented at VNN, but more work needs to be done. Data gathered from the years 1999 – 2004 confirm much of the findings from an earlier project from 1986 by Lystad, et al. Recent data suggest a seasonal shift in occurrence, primarily linked to the sea surface temperature. The group has lately been involved in a joint educational project between EUMETCAL and COMET, describing a case in the Norwegian sea, and also contributing with background material on forecasting of polar lows.

1-D-3.2 16:30-16:45

Polar Lows: An International Collaboration to Enhance Northern Latitude Forecasting

*Garry Toth, **Bruce Muller***
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The MSC/COMET Project and the European group, EUMETCAL, collaborated on the development of two polar low case studies, one North American and one European, and supporting instructional content. Together, these online training materials provide over 3 hours of interactive training on forecasting polar low events. Both case studies are presented as interactive exercises that allow the user to explore and discover the essential aspects of forecasting and tracking polar lows. Background theory is referenced throughout the case exercises and is also

available as a stand-alone reference tool. Forecasters from the MSC, the UK, Norway, Finland, and EUMETSAT collaborated with the COMET Program to analyze the cases, collect data, and write and review reference material. Both COMET and EUMETCAL will feature the case exercises on their Websites in order to reach a broad audience of forecasters and the meteorology training community.

1-D-3.3 16:45-17:00

Climatological Characteristics of Northern Hemisphere Winter Anticyclones

Lily Ioannidou, *Peter MK Yau*
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Based on the 14-year ECMWF Re-Analysis dataset that covers the 1979-1993 period and a sophisticated tracking model, we construct a global climatology of the Northern Hemisphere winter anticyclonic activity. The anticyclones' centers are identified as maxima in the mean sea level pressure field above a certain threshold. Their positions at consecutive timesteps are joined to form tracks and the evolution of their properties along their tracks is monitored with time. Statistical processing of the track data leads to identification of the regions of high concentration of anticyclonic activity of the Northern hemisphere and also of the relative positions of the centers of genesis and lysis of the anticyclones that develop in each region and of their particular characteristics.

In order to identify the driving mechanism for anticyclone development the analysis is repeated for the 500 hPa geopotential height, the 850 hPa and the 400 hPa temperature fields. The results highlight several aspects of the observed anticyclones, like their generation and dissipation mechanism, the evolution of their thermal structure during their lifetime, their mobility and intensity of growth.

Commonalities and differences between the anticyclones of different regions are examined and discussed in relation to the location of the corresponding region, the surrounding topography and relevant theoretical ideas. Special emphasis is put on the North American anticyclones for which our analysis shows that those that develop over the Western part of the continent are distinct from those that develop over the Eastern part, with respect to their vertical structure, forcing mechanism and their link to the global circulation.

1-D-3.4 17:00-17:15

Forecast Support to the Canadian Arctic Through-Flow Study, an Oceanographic Expedition to Nares Strait on the U.S. Icebreaker Healy, Summer 2003

Edward Hudson[1], *Humfrey Melling*[2], *Yves Sivret*[3]
[1]Canadian Meteorological Aviation Centre–West, Edmonton, AB, Canada
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[3]Canadian Ice Service, Meteorological Service of Canada (MSC), Ottawa, ON, Canada
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Summer 2003, Prairie and Arctic Storm Prediction Centre meteorologist Edward Hudson joined the U.S. Coast Guard icebreaker Healy in its voyage to Baffin Bay and through Nares Strait to the Lincoln Sea as part of the CATS (Canadian Arctic Through-flow Study) science team. The expectation and the reality of weather and ice conditions for the voyage will be shared. We found the region to be a lively playground for the mesoscale meteorologist. Weather "experiences" including a significant "hit" and a significant "bust" will be revealed. Oceanography and 'tourist' activity from the perspective of a meteorologist will be illustrated.

CATS http://newark.cms.udel.edu/~cats/ is a U.S. National Science Foundation sponsored 5 year study regarding freshwater fluxes through the Canadian Archipelago. Work is collaborative with American, Canadian and Japanese scientists.

1-D-3.5 17:15-17:30

Wind Forecast Investigation Tool (WFIT) – Application and Preliminary Results for Arctic Sites

Anke Kelker[1], *Edward Hudson*[2], *Erik de Groot*[2], *Bruno Larochelle*[2]
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[2]Canadian Meteorological Aviation Centre–West, Edmonton, AB, Canada
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Forecasters of the Canadian Meteorological Aviation Centre–West, Edmonton, have several “flavours” of wind guidance available to them including raw geostrophic winds, UMOS winds, Whitehorse adjusted winds, and FOCN10 winds. Accurate wind forecasts for example, are key to successful blowing snow and blizzard forecasts. Accurate wind forecasts are also important to the aviation forecast program for both area (GFA) and site specific (TAF) forecasts.

WFIT (Wind Forecast Investigation Tool) was developed to investigate the performance of the various wind guidance. WFIT offers the investigator access to skill scores, contingency tables, scatter plots and more. Using WFIT to mine the wind guidance versus observations, the merits of each guidance and hence how and when to use each guidance should be revealed. The expectation from managements' perspective is that results will show which wind guidance should be retained, supported, improved or retired thereby focusing support, computing and forecaster time.

WFIT became operational mid March 2004 and was used to investigate wind forecasts for 5 Nunavut sites: Baker Lake, Cambridge Bay, Iqaluit, Clyde and Resolute. This paper shares information on the development of WFIT and provides preliminary results and conclusions about wind guidance based on results for the five Nunavut sites.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00
**complete abstracts cited under Poster Session, pp. 167-178*

P-5 (1-D-3)
Topoclimate and Microclimate in Salluit Valley (Nunavik): Impacts on Permafrost Surface Temperature Topoclimat et microclimats de la vallée de Salluit (Nunavik): impacts sur la temperature de surface du pergélisol. ***Frédéric Bouchard***, *Nathalie Barrette*, *Michel Allard* (Département de géographie, Université Laval, QC, Canada)

P-6 (1-D-3)
Climatology of Adverse Weather Events in the Canadian Arctic. ***John Hanesiak***, *Teresa Fisico* (Centre for Earth Observation Science, University of Manitoba, Winnipeg, MB, Canada)

P-7 (1-D-3)
Forecast Support to the Canadian Arctic Through-Flow Study, an Oceanographic Expedition to Nares Strait on the U.S. Icebreaker Healy, Summer 2003. ***Edward Hudson***[1], *Humfrey Melling*[2], *Yves Sivret*[3] ([1]Canadian Meteorological Aviation Centre–West, Edmonton, AB, Canada; [2]Institute of Ocean Sciences, DFO, Sidney, BC, Canada; [3]Canadian Ice Service, Meteorological Service of Canada (MSC), Ottawa, ON, Canada)

P-8 (1-D-3)
Polar Lows and Forecasting. *Trond Lien*, *Jan Erik Paulsen*, ***Gunnar Noer***, *Magnus Ovhed* (Norwegian Meteorological Institute, Forecasting Division for Northern Norway, Tromsø, Norway)

1-D-4.1 16:00-16:15

An Examination of the Major Spatial Patterns of Growing-Season Agricultural Drought in the Canadian Prairies

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Palmer's Moisture Anomaly Index (Z-index) was used to characterize growing-season moisture conditions for 43 crop districts across the Canadian prairies during 1920-1999. The three main modes of spatial variability were identified using Principal Components Analysis (PCA), together they account for approximately 67% of the spatial variability in moisture conditions. The primary pattern (PC1) resembles a ‘bulls-eye’ with the largest moisture anomalies in the center of the study region (central Saskatchewan). PC1 has a strong positive correlation with the mean moisture condition of the entire study region. The negative phase of PC1 is associated with anomalously dry growing-season moisture conditions across the study region (e.g., 1961, 1988, 1936, 1929, and 1937) and the positive phase of PC1 is associated with anomalously dry growing-season moisture conditions (e.g., 1993, 1953, 1991, 1923, and 1954). The secondary pattern (PC2) represents the east-west variability in moisture conditions and the tertiary pattern (PC3) accounts for the presence of a north-south moisture gradient. The remaining variance in moisture conditions (~33%) can likely be attributed to local variations in convective activity.

Composite analysis was used to examine the atmospheric and oceanic anomalies associated with each of the spatial patterns. For example, the negative phase of PC1 (anomalously dry) is associated with enhanced ridging over western North America and enhanced troughing over eastern North America. As a result, there is increased meridional flow over the Canadian prairies during the growing season. The position of the jet stream is also shifted farther to the north during severe drought and storm tracks are steered away from the study region. The negative phase is also associated with La Niña-like conditions (negative SST anomalies) in the eastern equatorial Pacific. Generally, the atmospheric and oceanic anomalies associated with the positive (anomalously wet) phase of PC1 are opposite of the negative phase. These relationships should be explored further because they may form the basis for forecasting the occurrence of extreme wet and dry anomalies on the prairies.

1-D-4.2 16:15-16:30

On the Genesis of Prolonged Droughts in Canada

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Large-scale relationships between summer Palmer Drought Severity Index (PDSI) patterns in Canada and previous winter global SST patterns are analysed using maximum covariance analysis (MCA). The matrix for the covariance eigen-problem is solved in the EOF space in order to obtain the maximum covariance between the singular values of the SST and the PDSI. The robustness of the relationship is established by the Monte Carlo technique, in which the time expansion of the primary EOF analysis is shuffled 1000 times.

El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) explain approximately 48% of the squared covariance, thus making interannual ENSO phenomenon and ENSO-related interdecadal variability the most significant process in the determination of the summer moisture availability in Canada. The trend in global SSTs and multidecadal variation of the Atlantic

SST explain approximately one-third of the squared covariance. It is reflective of both the warming trend in the global southern oceans and the influences of the Atlantic Multidecadal Oscillation (AMO) variability. The six-month lag relationship between the PDSI and large scale SSTs provides a basis for developing long-range forecasting schemes for drought in Canada.

1-D-4.3 16:30-16:45

Atmospheric Circulation Patterns Associated with the 2001 and 2002 Canadian Droughts

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The 2001 and 2002 Canadian droughts were unusual events in terms of their vast spatial extent and extraordinary persistence. Extreme dry conditions encompassed most of southern Canada extending from interior British Columbia to the Atlantic Provinces during the summers of 2001 and to a lesser extent 2002. In addition, over the west-central Prairie Provinces, well below normal precipitation was recorded for a remarkable eight consecutive seasons from autumn 2000 through summer 2002. The mid-tropospheric circulation associated with these droughts generally explains the observed temperature and precipitation anomalies over various regions of the country. However, these circulation patterns were markedly different when compared to those associated with previous severe droughts over western Canada. Moreover, the evolution and persistence of the 2001 to 2002 droughts have no clear relationships with large-scale teleconnection patterns that have been shown to influence past climate extremes over the country. Results suggest that the dry conditions were related to a northward extension of positive 500 hPa height anomalies over the continental United States that persisted for several seasons. However, further research into this possible link is required.

1-D-4.4 16:45-17:00

Small Scale Characteristics of Canadian Prairie Drought

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Typically, drought occurs once every three years across the Canadian Prairies. Most research addressing such droughts has concentrated on the large scale conditions associated with this form of extreme weather whereas little research has been conducted on its smaller scale characteristics. The present research begins to address the latter issue. Several datasets (surface observations, re-analysis products and satellite information) were used to identify the 11 most severe droughts occurring over the Prairies since 1953 and these were subsequently analyzed. First, in comparison with normal or wet conditions, the diurnal cycle of temperature, moisture, cloud and precipitation during severe drought (Palmer Drought Index < -4) or drought shows systematic variations. Hot and dry conditions during severe drought lead to the highest cloud bases preventing significant precipitation from occurring in late afternoon and thereby reinforcing the dry conditions. Second, there is an apparent increase in middle and upper level cloud during severe drought; moisture is still available but it is concentrated aloft. Third, the major storms significantly reducing the extent of severe droughts are generally due to widespread frontal lifting as opposed to being locally-driven thunderstorms. Collectively, such research results provide a unique, important perspective on the nature of Prairie droughts.

1-D-5.1 16:00-16:15

Winter Lightning Climatologies – the Reality

Peter J Lewis*, William R Burrows*
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Since the Canadian Lightning Detection Network (CLDN) became operational in the summer of 1998 it has been demonstrated that the occurrence of Winter Lightning over the Maritime Provinces of Canada is far more common than had been inferred by historical climatologies of point observations of thunderstorms (Thunderstorm Day Climatologies). In this study the lightning characteristics of a severe lightning storm which occurred over Nova Scotia in January 2000 are investigated. This event necessitated the issuance of a severe thunderstorm warning from the Maritimes Weather Centre. Several power outages were reported during the storm.

As well as lightning characteristics, the dynamic meteorological conditions responsible for the thunderstorm formation are investigated and compared to other winter thunderstorm events described in the literature. Winter lightning events over offshore waters typically involve outbreaks of cold continental air over relatively much warmer water surfaces. This storm was atypical. Land surface temperatures were above freezing and lightning occurred over the relatively cool inshore waters. The storm produced in excess of 8000 cloud to ground strikes over a 9 hour period with about one third of those having positive charge. Preliminary investigation suggests synoptic scale destabilization at low to mid-levels caused by an upper cold front. It appears that the temperature structure at mid-levels was optimum for snow crystal growth and charge separation.

1-D-5.2 16:15-16:30

Convective Precipitation and Cloud to Ground Lightning Relationships in Canada

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Convective precipitation and lightning are two physically related phenomena of thunderstorms. Several studies have calculated rain yields over various temporal and spatial scales for different climatic regimes around the world, however, such studies have not been carried out across Canada. In this study, ten weather stations reflecting different precipitation regimes across Canada were selected.

The study period comprised the months of April to October from 1999 to 2003. The components of rain yield, namely, C-G lightning flashes and rainfall were obtained from the Canadian Lightning Detection Network, and the daily rainfall measurements reported at each of the stations on confirmed thunderstorm days from the MSC surface weather archive. All C-G lighting strikes detected within a 20-km radius of each station were used in the calculation of the rain yield. We assumed the same rain depth over the entire 20-km radius, and calculated the rain yield by taking the ratio of the volume of precipitation to the total number of C-G flashes.

We further stratified the thunderstorm days as either wet or dry according to the precipitation amount recorded at the station. Thunderstorm days were considered wet if the rainfall amount was

greater than 3 mm, and dry if the rainfall amount was less than 3 mm. Some results examining the relationship between convective precipitation yield and cloud-to-ground lightning for these selected stations will be presented and discussed.

1-D-5.3 16:30-16:45

1 to 2 Day Prediction of the Probability of Lightning Occurrence over Canada and the Northern United States in the Warm Season

***William R Burrows*[1]**, *Colin Price*[2], *Laurence J Wilson*[1]
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Statistical models valid for each month May to September were developed to predict the probability of lightning occurrence in three hour intervals for a large geographical region encompassing much of Canada and the northern United States. Lightning is an episodic phenomenon that generally occurs over a small fraction of this region in a three-hour period, even on significant days in the warm season. Many predictors are required to successfully forecast lightning occurrence for this large area with statistical models.

Dynamic predictors were derived from output of the GEM weather prediction model at the Canadian Meteorological Centre. Climate control predictors such as significant land-water boundaries were included. Statistical models were built for 5-degrees latitude-longitude bands with a non-linear tree-structured regression algorithm using data from 2000 and 2001, and run in real time at CMC during the summer of 2003. Error reduction in the predictand achieved by most of the models was in the range .4 to .7.

The most important predictors overall were the Showalter index of convection, mean sea-level pressure, and precipitable water. Analysis of predictor importance rank in several portions of the prediction region showed the three-hour average of dynamic predictors ranked higher than the maximum or minimum value, possibly since the predictand was derived from three hour total lightning. Three-hour changes of 500 hPa geopotential height, thickness, and mean sea level pressure were highly ranked predictors in many areas, likely since they are representative of frontal motion. CAPE was not ranked among the ten most important predictors in any portion of the prediction region. Verification of 2003 forecasts in six-hour intervals showed lightning occurrence was predicted with a good degree of success on most days.

1-D-5.4 16:45-17:00

Verification of a Lightning Forecast Model during A-GAME

William R Burrows[1], ***Bohdan Kochtubajda***[2], *Monique Lapalme*[2]
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The prediction of weather phenomena can take advantage of automated networks that have been established over the last few years, and is an important component of weather warning activities. Evaluating probability forecasts for dichotomous events, such as the occurrence of lightning versus no lightning is an important issue in forecast verification. Lightning is a highly non-linear atmospheric phenomenon that requires complex models to predict its occurrence.

A statistical model developed to predict probability of lightning occurrence in 3-hour intervals to 48 hours for Canada and the northern USA (Burrows, 2002), was run in real-time from the Canadian Meteorological Centre (CMC) during the Alberta GPS Atmospheric Moisture Evaluation (A-GAME) field program. A-GAME was carried out in central Alberta from July 14-26, 2003.

1-D-5.5 17:00-17:15

A Severe Winter Lightning Storm over Nova Scotia and Adjacent Waters – January 2000

Peter J Lewis
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Contact: peter.lewis@ec.gc.ca

Since the Canadian Lightning Detection Network (CLDN) became operational in the summer of 1998 it has been demonstrated that the occurrence of Winter Lightning over the Maritime Provinces of Canada is far more common than had been inferred by historical climatologies of point observations of thunderstorms (Thunderstorm Day Climatologies). In this study the lightning characteristics of a severe lightning storm which occurred over Nova Scotia in January 2000 are investigated. This event necessitated the issuance of a severe thunderstorm warning from the Maritimes Weather Centre. Several power outages were reported during the storm.

As well as lightning characteristics, the dynamic meteorological conditions responsible for the thunderstorm formation are investigated and compared to other winter thunderstorm events described in the literature. Winter lightning events over offshore waters typically involve outbreaks of cold continental air over relatively much warmer water surfaces. This storm was atypical. Land surface temperatures were above freezing and lightning occurred over the relatively cool inshore waters. The storm produced in excess of 8000 cloud to ground strikes over a 9 hour period with about one third of those having positive charge. Preliminary investigation suggests synoptic scale destabilization at low to mid-levels caused by an upper cold front. It appears that the temperature structure at mid-levels was optimum for snow crystal growth and charge separation.

1-D-5.6 17:15-17:30

The Canadian Wildland Fire Information System

Kerry R. Anderson, *Richard Carr, Peter Englefield, Kelvin Hirsch, John Little, Rod Suddaby,*
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The Canadian Wildland Fire Information System is an operational fire information system that monitors forest fire danger and activity across Canada. For fire danger monitoring, weather observations are obtained from over 800 stations via the Anik satellite. The Canadian Forest Fire Danger Rating System, implemented in a GIS application, is used to produce national maps of fire weather and potential fire behaviour. For large fire activity monitoring, hotspots and smoke are identified from infrared satellite imagery and used to produce national maps as well as regional images of major wildfire and smoke events at full (1 km) resolution. Maps and reports are made available on the web (http://cwfis.cfs.nrcan.gc.ca/) and updated daily.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00
**complete abstracts cited under Poster Session, pp. 167-178*

P-9 (1-D-5)
Fire Determines the Surface Energy Balance of the Canadian Forest Mosaic. ***A Orchansky***[1], *B Amiro*[1], *A Barr*[2], *TA Black*[3], *JH McCaughey*[4] ([1]Canadian Forest Service, Edmonton, AB, Canada; [2]Meteorological Service of Canada (MSC), Saskatoon, SK, Canada; [3]University of British Columbia, Vancouver, BC, Canada; [4]Queen's University, Kingston, ON, Canada)

P-10 (1-D-5)
In Situ Air Quality Monitoring of Smoke from Prescribed Burns of Boreal Forest in the Mountains of Banff National Park, Alberta, Canada. ***Brian J Wiens***[1], *Shauna Durocher*[1], *Patrick Kyle*[1], *Mark Heathcott*[2] ([1]Environment Canada, Edmonton, AB, Canada; [2]Parks Canada, Edmonton, AB, Canada)

2-A.1
Remote-Sensing and New Technologies: a New Era
La télédétection et les technologies d'Àvant-garde: une ère nouvelle

08:35-09:20
Plenary

Virendra Jha
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Remote-sensing technology has proven its merits as an excellent complement to existing monitoring methods. As new processing technologies become available and the number of space-based sensors increases significantly, information is now widely available. The convergence of navigation, telecommunications and Earth Observation technologies is now enabling end-users to access data in near real-time – a critical capability for areas concerned with the human dimensions of weather and climate, such as disaster management.

With advances in multimedia technologies, on-board processing, and distributed processing on the ground, information is now available to provide policy-makers with a clear picture for the judicious management of the planet's natural resources. Yet there is a need for increased collaboration--as well as increased awareness – if we are to use remote-sensing technologies efficiently. This session will focus on future technological innovations with the advent of Canadian projects like Radarsat-2, hyperspectral technology, and future satellite missions like Hydros and CloudSat, and will address some of the challenges yet to be surmounted to ensure that Earth Observation information is used to its full potential.

Il a été clairement démontré que la technologie de la télédétection constitue un excellent complément aux méthodes de surveillance existantes. À mesure que les nouvelles technologies de traitement font leur apparition et que le nombre de capteurs spatiaux s'accroît de façon significative, la disponibilité de l'information gagne également du terrain. La convergence des technologies de navigation, de télécommunication et d'observation de la Terre permet aux utilisateurs finaux d'avoir accès à des données en temps quasi réel. Cette capacité s'avère déterminante dans des domaines comme la gestion de catastrophes, où la dimension humaine de la météo et du climat prime.

Grâce aux percées en matière de technologies multimédias, de traitement embarqué et de traitement des données réparti au sol, l'information est à la portée des décideurs qui ont désormais en main tous les éléments pour effectuer une gestion judicieuse des ressources naturelles de la planète. L'utilisation optimale des technologies de télédétection passe toutefois par la collaboration et la sensibilisation. La présentation portera sur les futures innovations technologiques mises de l'avant dans le cadre de projets canadiens tels que RADARSAT-2, le développement de la technologie hyperspectrale et les futures missions satellitaires Hydros et CloudSat. L'accent sera également mis sur quelques-uns des défis qui doivent être relevés afin que l'information issue de l'observation de la Terre soit utilisée à son plein potentiel

2-A.2

09:20-10:05
Plenary

Ocean Modeling using Mixed Spectral/Finite Element/Finite Volume Methods

DB Haidvogel[1], *M Iskandarani*[2], *J Levin*[1]
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A number of new ocean circulation models based on unstructured finite element and finite volume methods have been developed over the past few years. Their main advantage is the geometric flexibility inherent in their computational grids that allows them to easily handle complicated coastlines, and that endows them with a natural multi-resolution capability. A number of computational issues remain unresolved with respect to the general application of these methods, however. Prominent among these are issues relating to the combined treatment of tracer advection, strong stratification and/or steep topography.

Here we review several algorithms designed for h-p-type finite element and finite volume methods, and contrast their behaviors in the limits of advection- and/or topographically dominated oceanic flows. The emphasis is on studying, by numerical examples, the properties of these schemes in terms of accuracy, stability and monotonicity. Comparisons are conducted for several canonical oceanic test problems, including: tracer advection through a western boundary current, stratified flow past a tall seamount, and tidally driven residual circulation at a coastal canyon.

2-B-1.1 10:30-11:00 Invited

Creating an Aviation Centre of Excellence

Steve Ricketts
Environment Canada, Canadian Meteorological Aviation Centre–West, Edmonton, AB, Canada
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A key component of the current restructuring of the Meteorological Service of Canada (MSC) is the consolidation of aviation weather forecasting into two centres (one in Edmonton, the other in Montréal). These aviation centres will work closely together to provide all forecast services under a contract that the MSC has with NAV CANADA, which runs the Air Navigation System in Canada. Consolidation is needed to create a more efficient structure that can better focus on the specific needs of aviation users.

The short-term focus of the MSC is to transfer forecasting duties from several centres across Canada to the two centres. This work is well underway and should be completed by early May 2004. The longer-term focus is on how to address the needs of aviation users in the future – the overall goal being to create an aviation centre of excellence. The MSC has expertise in aviation weather forecasting and needs to remain a scientifically-valid source of information and advice to the aviation community. In addition to producing TAFs (terminal forecasts) and GFA (graphic area forecast) charts, MSC activities in the future will encompass new charts and services, an investment in aviation-oriented R&D, and outreach to the aviation community.

There are many external factors and influences to be considered, including continuing improvements in numerical weather models and weather element guidance, a slow but gradual rebound in the aviation economy, a growing demand for better aviation weather products, and a move internationally to producing and sharing aviation weather guidance in digital format. A key factor is a demand for North America-wide products in graphical format, which will need to be harmonized across the Canada-US border (and over oceanic areas), requiring coordinating with weather centres in other countries.

The presentation will focus on MSC's ability to meet these challenges and present ideas on a plan of action to prepare for the future. It will cover new products, software tools needed to produce them, training needed for aviation forecasters, and ways to make our information more useful and understandable by aviation users. It will also cover mechanisms by which MSC could coordinate aviation research and development efforts in support of the operational aviation forecasting program.

2-B-1.2 11:00-11:15

Discarding the Forecast Funnel

Kent A Johnson
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Traditionally, the forecast process, both in education and operations, has been referred to as a funnel. The funnel represents starting at the large scale and cascading to the local scale. Before the recent advances in numerical weather prediction (NWP), this process was essential as the forecaster had to first assess and predict all the large scale forcing and then apply these on the

local scale, such as a city forecast or an aerodrome forecast. However, forecaster ability to supersede NWP is decreasing rapidly and skill atrophy is occurring. It is necessary to critically examine the forecast process and, correspondingly, education and training in applied meteorology.

The current operational forecast system focuses primarily on the next few days. Thus, forecasters tend to start with the synoptic scale, often resulting in a lack of focus on detailed analysis and diagnosis and, instead, a prime focus on NWP fields. Since effective intervention at the larger scales is becoming more rare, the forecaster should start focusing on the analysis and on smaller scale processes. Learning approaches should be similar, first teaching phenomena such as slantwise convection (position and motion of bands), upright convection, cloud height, aviation icing, gap winds, coastal winds, gust fronts, orographic precipitation, ventilation, katabatic winds and mountain waves. Most of these topics can be taught without the need for quasi-geostrophic theory or even the coriolis term in the equations of motion. With modern tools including NWP, the operational forecaster is likely to add value at smaller and smaller spatial scales. By rejecting the forecast funnel and starting with a strong foundation in mesoscale processes, meteorologists will be better prepared for the future. Such a cultural change will have to begin in the formative stages, in education and training of meteorologists.

2-B-1.3 — 11:15-11:30

Verification of Public and Commercial Temperature Forecasts

Patrick J McCarthy
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Daily temperature forecasts are provided by both national and weather services. National weather services rely on human input from meteorologists and the input from numerical weather models to produce their forecasts. Major private weather forecast companies have some human input into the process but more typically rely on numerical output from the national weather services to produce their forecasts. To the consumer, there are many sources of weather forecasts available to them from these various forecast providers. This abundance of information can make it difficult for the consumer to identify which is the more accurate forecast. For national weather services, it is increasingly difficult to justify the ongoing production of routine weather forecast when so many private companies are producing them.

This presentation will examine the performance of daily maximum temperature forecasts for the City of Winnipeg. These forecasts were provided by Environment Canada and by four private national and international providers. The daily temperature forecasts, including medium to long range forecasts if available, were collected at the same time each morning and the error was calculated with respect to the actual day-time maximum temperature. The presentation will also examine the "value" of the resulting performance as determined by public expectations. Finally, the presentation will provide insight into the value of using ensembles to produce these forecasts.

2-B-1.4 11:30-11:45

A Fuzzy Logic-based Analog Forecasting System for Ceiling and Visibility

Bjarne Hansen
Cloud Physics Division, Meteorological Research Branch, Meteorological Service of Canada (MSC), Dorval, QC, Canada
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WIND-2 is a prototype analog forecasting system that produces probabilistic predictions of cloud ceiling height and horizontal visibility at airports. For data, it uses historical observations (climatology), current observations (METARs), and model based guidance. To find analogs, it uses a fuzzy logic based algorithm to measure similarity between historical conditions and current conditions (a composite of recent METARs and model based guidance). It uses the found analog ensemble (or nearest neighbours) to make probabilistic predictions of ceiling and visibility in the 0-to-24 hour projection period. WIND-2 has been tested by running continuously for over a year for 12 major Canadian airports, and it produces highly accurate forecasts, based on summaries of POD, FAR, and CSI statistics, and compared to benchmarks (persistence and TAFs). Work is underway, at the Meteorological Research Branch (MRB) of MSC, to develop an upgraded system, to be called WIND-3. WIND-3 will produce ceiling and visibility predictions for all major Canadian airports, at 1-hour resolution, updated each hour. A near-real time validation scheme and that some validation statistics will accompany the system. For illustration purposes, examples of successful and unsuccessful forecasts will be shown, and the reasons for their success and lack of success will be discussed.

2-B-2.1 10:30-11:00 Invited

Canada and the Global Precipitation Measurement Mission

Paul Joe
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The Global Precipitation Measurement mission is a proposed follow-on to the Tropical Rainfall Measurement Mission. A main aim of the project is to remotely measure precipitation accurately, with temporal sampling to resolve the diurnal cycle, and with global coverage. A constellation of satellites carrying microwave radiometers will provide the temporal sampling. A core satellite will carry dual-frequency radar for validation and algorithm development. Eight satellites will provide a three hour sampling capability and coverage will nominally be up to 60° latitude.

The Canadian and European Space Agencies are collaborating on contributing a satellite with an instrument payload capable of measuring light precipitation and snow over ocean and land. Innovative microwave technology capabilities include high frequency channels (89, 118, 157, ghZ) and oxygen channels (50, 53, 54, 55) and a high sensitivity single frequency (35 GHz) radar is proposed. In addition, this satellite will provide coverage up to 83o latitude. Recent studies have been conducted to establish the snow and light rain detection requirements and to demonstrate the feasibility and necessity of these novel technologies.

The proposed mission is very exciting and could stand alone based on its scientific merit. The mission will provide new information on precipitation variability, precipitation processes particularly over remote regions where there is little or no information and contribute to better atmospheric, cryospheric and hydrological predictions.

2-B-2.2 11:00-11:15

Detection and Monitoring of Precipitation from Space: Winter Case Studies

Irene G Rubinstein
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Weather radar provides precipitation information for regions close to the 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 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 can also provide information about the vertical distribution of hydrometeors within large precipitation cells.

In this work we present preliminary results of analysis of winter precipitation events. Time and space collocated satellite imagery, Doppler weather radar and McGill University vertical profiler radar were analyzed for several winter seasons. Although quantitative evaluation of winter precipitation intensity was not as reliable as for the extreme summer events, the combined analysis of upward-looking radar and spaceborne imagery provided very interesting results. In this presentation we will discuss these results, as well as, potential of using existing radar sites for calibration and validation of retrieval algorithms for current and future spaceborne sensors.

2-B-2.3 11:15-11:30

Sea-Ice Motion Estimation using the Advanced Microwave Scanning Radiometer for EOS (AMSR_E)

Tom Agnew
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The new Microwave Advanced Scanning Radiometer on the EOS Aqua platform (AMSR_E) provides improved spatial resolution especially in the highest frequency (89 Ghz) spectral channels compared to earlier passive microwave sensors. This allows improved accuracy in estimating a number of geophysical properties of sea-ice such as sea-ice concentration and sea-ice motion. In this paper a comparison is made of large scale sea-ice motion over the Arctic Ocean estimated from AMSR_E image pairs and Arctic drifting buoy data. These results are considerably better than results from earlier microwave sensors such as the Special Sensor Microwave Imager (SSM/I).

The paper will discuss how AMSR_E sea-ice concentration estimates can be combined with sea-ice motion to estimate the area flux of sea-ice within the Arctic Ocean and between the Arctic Ocean and the North Atlantic and even the area flux of sea-ice through the main channels of the Canadian Archipelago. The flux of sea-ice out of the Arctic through Fram Strait and the Canadian Archipelago is recognized as an important component of the freshwater budget of the Arctic Ocean and a knowledge of its variability is important for validating Arctic Climate Models and detecting climate change.

2-B-2.4 11:30-11:45

Regional Validation of Passive Microwave Satellite Derived Snow Water Equivalent in Canada

Chris Derksen, *Anne Walker, Barry Goodison*
Climate Research Branch, Meteorological Service of Canada (MSC), Downsview, ON
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Algorithm development at the Climate Research Branch of the Meteorological Service of Canada (MSC) has produced the capability to utilize spaceborne passive microwave data to derived information on snow water equivalent (SWE) over Canadian landscape regions. Passive microwave satellite data have been available since 1978, and are presently used in Canada for operational water resource management, climatological time series analysis, and regional climate model initialization and evaluation. Enhanced passive microwave remote sensing capabilities are now available with the recent launch (December 2002) of the Advanced Microwave Scanning

Radiometer (AMSR-E) onboard the NASA Aqua platform, while a future generation of passive microwave technology is being planned within the NASA Cold Land Processes Mission (CLPM).

The purpose of this presentation will be to report on a series of recent (2002 – 2004) field campaigns led by the Climate Research Branch, both for MSC SWE algorithm evaluation, and as a contribution to NASA AMSR-E validation activities:

- During February 2002, ground, tower, and airborne passive microwave datasets were acquired to evaluate SWE variability within a mixed boreal forest environment in central Saskatchewan. Results indicate that spaceborne SWE retrievals adequately characterize mean grid cell SWE, but enhanced consideration of within grid cell land cover is required to provide estimates on the range of SWE evident within the large spaceborne passive microwave imaging footprint (625 km^2).
- Snow surveys were conducted along an approximately 500 km measurement transect across northern Manitoba during November and March 2003/04. While SWE estimates in the northern boreal forest agreed well with in situ measurements, retrievals over the open tundra were anomalously low, a finding attributed largely to the lack of consideration of within-grid cell lake coverage in the MSC algorithm suite.
- Snow surveys were conducted in a series of open tundra watersheds near Daring Lake, NWT (2003/04) to initiate the development of a tundra-specific SWE retrieval algorithm that considers the high density tundra snowpack, and the unique microwave properties of surface water (frozen lakes).

Collectively, data acquired through these field campaigns will lead to an improved capability to estimate SWE from spaceborne passive microwave data, for a range of land cover and snowpack conditions.

2-B-2.5 11:45-12:00

Satellite Winds Assimilation with CMC Operational NWP System

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Wind observations derived from geostationary satellites imagery have been used in the Canadian Meteorological Centre (CMC) global and regional NWP systems for many years. The observations are provided in BUFR format by NOAA/NESDIS for GOES-E/W satellites, EUMETSAT for METEOSAT-5/7. Until now, SATOBS bulletins from JMA were used for the western pacific region. The presentation will focus on recent fine tuning done in the selection and quality control of satellite winds in CMC 3D-Var assimilation. BUFR format bulletins provided by JMA and containing data from GOES-P (GOES-9) satellite are being tested. Some tightening of the rejection condition in the QC-Var is done. The selection and thinning procedure is partly based on the quality indices provided with these observations. This fine tuning provides a slight improvement in the quality of CMC forecasts. Because of the viewing angle, no high latitudes winds are available from the geostationary satellites. The analyses in the polar region suffer from the low density of conventional radiosondes or aircraft wind observations.

The Cooperative Institute for Meteorological Satellite Studies (CIMSS) has recently adapted the wind retrieval procedure to the MODIS instrument on-board Terra and Aqua, NASA polar orbiting satellites. Wind observations are derived from image triplets of water vapour and infrared channels, in the region poleward of 65°. Early studies have shown the potential of these new observations. Recent assimilation and forecasts experiments conducted with the CMC global NWP system show an improvement in the quality of the forecasts with the inclusion of the polar wind observations in the 3D-Var assimilation. The selection and thinning procedure is similar to the one used with the geostationary satellites.

The results of the winter 2003-2004 impact trial will be presented. The benefit of the addition of the polar wind observations is more obvious in the polar region but extends to a certain degree to the whole hemisphere. This is especially true in the southern hemisphere. New observing system experiments with no satellite winds, confirm the positive impact of this type of observations in the CMC 6-hourly 3D-Var assimilation system.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00
**complete abstracts cited under Poster Session, pp. 167-178*

P-11 (2-B-2)
Sea Surface Salinity from Space: a Canadian Perspective. *BJ Topliss[1], JFR Gower[2],* ***IG Rubinstein[3]****, JA Helbig[4], E Simms[5]* ([1]Bedford Institute of Oceanography, Fisheries and Oceans Canada, Dartmouth, NS, Canada; [2]Institute of Fisheries and Oceans Canada, Sidney, BC, Canada; [3]York University, Toronto, ON, Canada; [4]Atlantic Fisheries Centre, Fisheries and Oceans Canada, Ottawa, ON, Canada; [5]Memorial University, St. John's, NL, Canada

2-B-3.1

10:30-10:45

Modelling Long-Term Hydrography Changes in the North Atlantic

***Daniel G Wright**, Youyu Lu, Igor Yashayaev*
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Recent studies have revealed a large scale freshening in the North Atlantic since the 1960s and documented the contemporaneous changes in the density stratification in the intermediate, deep and bottom waters. To investigate the causes and impacts of these large changes in the hydrography, we conduct a series of sensitivity experiments using a coarse resolution version of the Parallel Ocean Program (POP) model of the Atlantic Basin from 30S to 70N. Each simulation includes a 10 year spin-up under climatological conditions plus integration over the 50-year period from 1949-1998 with monthly surface fluxes obtained from the NCEP/NCAR reanalysis. Initial simulations have climatological conditions specified at the open boundaries in order to determine that part of the variability that is determined by local forcing and internal dynamics. An additional simulation is then performed with conditions in the northern sponge layer determined by the observed hydrographic data. In each case, we examine the ability of the model to reproduce observed long-term changes in the temperature and salinity of the Irminger and Labrador Seas. The interannual variations in the hydrography of the model will be related to changes in surface forcing, open boundary conditions and changes in the model's meridional circulation.

2-B-3.2

10:45-11:00

Towards an Operational Analysis and Forecast System for the North Atlantic Ocean: Initial Implementation and Forecast Skill Assessment

*Entcho Demirov[1], Youyu Lu[2], **Keith R Thompson**[1], Daniel G Wright[2]*
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University and government researchers from the Center for Marine Environmental Prediction (CMEP) are developing an operational ocean forecast system with the capability of assimilating remotely sensed and in situ data. The time and space scales of interest are of order 1-102 days and 10-104 km, respectively. The dynamical module of the system is the Parallel Ocean Program (POP). The model domain covers the Atlantic Ocean from 7°N to 67°N with a horizontal resolution of 1/3° x 1/3°cos (latitude) and 23 levels in the vertical.

To overcome the common problem of model drift, and to provide a realistic background state that can act as an energy source for the growth of instabilities and hence eddies, 'frequency dependent nudging' is used. This method ensures that the model's seasonal climatology (as opposed to its instantaneous state) does not drift too far from an observed seasonal temperature and salinity climatology.

Altimeter measurements of sea level are also assimilated using the approach of Cooper and Haines (1996). It is first shown that when the model assimilates only the observed seasonal temperature and salinity climatology it reaches a realistic statistical steady state: seasonal variations in sea surface height agree with tide gauge observations and rms sea surface height variability agrees with that calculated from gridded altimeter data. A ten year hindcast experiment is next described. The model is first spun up for 25 years forced by monthly mean winds and surface heat and water

fluxes with the observed seasonal climatology assimilated. During the subsequent hindcast period, from 1991 to 2000, surface forcing is computed from (i) daily mean NCEP momentum and heat fluxes, and (ii) monthly mean precipitation data (see Xie and Arkin), and both the observed seasonal climatology and weekly mean altimeter maps are assimilated. The model forecast skill scores are evaluated and compared against those of existing forecast systems for the North Atlantic.

The presentation concludes with a discussion of next steps, including the assimilation of vertical profiles of temperature and salinity measured by Argo floats, and the long-term goal of coupling a global version of the ocean system to a global atmospheric model.

2-B-3.3 11:00-11:15

Simulation of the Northeast Pacific using Various Nudging Schemes

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The Parallel Ocean Program (POP) is being used to simulate the circulation of the North Pacific Ocean. Our specific area of interest is the Northeast Pacific. The model has 0.25 degree horizontal spatial resolution and 23 vertical levels. It is initialized with Levitus temperature and salinity, and forced with COADS monthly climatological heat flux and winds. The circulation starts from rest and the simulation time for each model run is 20years.

Two different nudging techniques are tested and compared to a simulation that does not use nudging. One nudging technique is 'standard nudging', wherein the total model temperature and salinity are nudged towards monthly Levitus climatology. The other nudging technique is 'frequency-dependent' nudging, wherein only the low-frequency components of the model temperature and salinity are nudged toward monthly climatology. The validity of the simulations is investigated by comparing the simulated sea-surface height statistics to those obtained from satellite altimetry data.

2-B-3.4 11:15-11:30

Design of Data Assimilation System for North Pacific Ocean Circulation

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Data assimilation system is under development at the Institute of Ocean Sciences based on IPEZ(Inverse Primitive Equation Z-coordinate model)package developed by Chua and Bennett (2001) at the Oregon State University. The goal of the system is to create a best estimate of the Pacific Ocean state during last decade (1992-2002). We solve weak 4DVAR problem using the representer approach in this system. Assuming that the dynamics is weakly nonlinear for the basin scale ocean circulation, each representer describes spatial and temporal structure of impact from a corresponding datum to optimal solution. Since the representer structure is determined by model error covariance matrix and model's forward and adjoint operators, we need to search for the best balance between model error covariance and dynamics along our purpose.

In the current system, error covariance matrix is designed to be univariate while multivariate structure of the representers solely depends on dynamical operator, which changes its dominant balance according to a data assimilation period. In this presentation we discuss the sensitivity of the analysis to a size of model error covariance matrix and the length of the assimilation period.

2-B-3.5 11:30-11:45

Storm-Induced Circulation on the Scotian Shelf and Slope using Two-Way Nested-Grid Ocean Circulation Modelling System

***Jinyu Sheng**, Xiaoming Zhai, Richard J Greatbatch*
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The Scotian Shelf and slope are affected frequently by winter storms and extratropical storms, and occasionally by hurricanes such as Gustav in 2002 and Juan in 2003. The main objective of this study is to study the storm-induced circulation and temperature/salinity variations on the Scotian Shelf and slope using a two-way nested-grid ocean circulation modelling system. The nested-grid modelling system consists of a fine-grid inner model for the Scotian Shelf and slope and a coarse-grid outer model for the northwest Atlantic Ocean.

A new and novel two-way nesting technique based on the smoothed semi-prognostic method is used to exchange information between the two grids over the common subregion where the two grids overlap. The nested-grid modelling system is used to study the response of the Scotian Shelf and slope to Hurricanes Gustav in 2002 and Juan in 2003. Before the storm reaches the shelf, the storm-induced circulation in the deep ocean is characterized as intense inertial oscillations in the upper ocean and rightward bias of the sea surface temperature cooling. As the storm moves onto the shelf, barotropic shelf waves are excited and propagate away from the storm track with the coast to their right.

2-B-3.6 11:45-12:00

Strategy for the Development of an Operational Canadian Global Assimilation and Prediction Capability for the Coupled Atmosphere-Ocean-Ice System

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The Meteorological Service of Canada (MSC), the Department of Fisheries and Oceans (DFO), and the Department of National Defence (DND) all need the products and modelling capabilities that can be provided by an operational global coupled atmosphere-ocean-ice data assimilation and prediction system. Several weather and climate prediction centres around the world are reporting improvements resulting from good representations of interactions with the oceans.

In Canada recent improvements in basin and global-scale ocean models, data assimilation, 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 2005. 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.

In the summer of 2002 these points were considered in a two-day 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.

As a follow-on to this workshop, an inter-departmental advisory panel (Doug Bancroft (DFO), Hal Ritchie (EC), Andy Cameron (DND) and Keith Thompson (Dalhousie University)) was established to make specific recommendations on an operational Canadian coupled modelling capability. The panel has investigated the need, opportunity and feasibility of developing and implementing an operational Canadian atmosphere-ocean-ice modelling system. The panel has formulated recommendations to be considered by EC, 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 Congress, with an emphasis on the potential uses in forecasting the weather and climate of the atmosphere and ocean.

2-B-4.1

10:30-11:00
Invited

Climate Variability in the Mackenzie Basin: Observations, Theory and Modelling

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The Mackenzie River Basin is observed to exhibit large interannual variability in its hydroclimate. In particular, the region possesses the largest interannual variability in winter atmospheric temperatures in the Northern Hemisphere, and it also exhibits large interannual variability in its summer precipitation and runoff. In addition, some of the strongest recent warming signals on the planet were also found in this region. One of the major objectives of the Mackenzie GEWEX Study (MAGS) is to improve our physical understanding of the causes of climate variability in the region. The observed climate variability in the basin, as well as physical insights into nature of the observed variability that are gained from MAGS research will be addressed in the presentation. Preliminary assessments of the CRCM's performance in simulating the observed variability for the basin will also be discussed.

2-B-4.2

11:00-11:30
Invited

The Pacific North American Pattern – an Overview

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The Pacific North American (PNA) pattern is one of the two leading extratropical Northern Hemisphere modes of variability on the seasonal time scale. The presentation will provide a survey of the basic characteristics of the PNA pattern, of the mechanisms that generate and maintain it, and of its role in the predictability of mean-seasonal atmospheric conditions. The interplay between the PNA and the travelling weather disturbances will be illustrated, showing how on the one hand the PNA alters the storm tracks, and how, on the other hand, the travelling weather disturbances feedback onto the PNA pattern itself. The influence of the EL Niño / Southern Oscillation on the skill of seasonal forecasts, through the presence of the PNA, will be illustrated.

2-B-4.3

11:30-11:45

Association of an Upstream Blocking Regime upon Mackenzie River Basin Temperature and Precipitation Structures during the Boreal Cold Season

Marco L Carrera[1], ***John R Gyakum***[2]
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In this study we examine the relationships between atmospheric blocking over the Northeast Pacific, and weather extremes over the Mackenzie River Basin (MRB) during the boreal winter seasons from 1979 through 2000. A total of 37 atmospheric blocking events are found with durations ranging from 8 to 25 days and a mean duration of 11.3 days. A total of 15.6% of the days during the boreal winter belonged to a blocking event. The mature Northeast Pacific block

possesses characteristics that are typical of blocking episodes, including the equivalent barotropic structure of the blocking anticyclone, the meridional flow both upstream and downstream of the block, the equatorward shift of the Pacific storm track, and downstream development over North America.

The surface temperature analysis revealed a significant shift in the daily mean surface temperature distribution during blocking toward colder temperatures in the region extending from the Yukon southeastwards to the southern Plains of the United States (US), associated with a reduced variance of surface temperatures. Over extreme western Alaska there is a shift in the daily mean surface temperature distribution toward warmer temperatures. The shift toward colder (warmer) daily mean surface temperatures is also accompanied by a shift in the skewness of the distribution toward more extreme cold (warm) days in these two regions. The precipitation structures over the MRB during the blocking regime are influenced largely by the equatorward shift of the North Pacific storm track.

The climatological southwesterly moisture flux into coastal British Columbia is shut down, with the zone of southwesterly moisture flux shifting equatorward toward the US West coast and northern Mexico. The north/south dipole in precipitable water anomalies along the west coast of North America is consistent with the shift in storm track. We plan to examine the changes in the statistical distributions of precipitation over the MRB during the blocking regime using the recently completed North America Regional Reanalysis. We expect a significant decrease in MRB precipitation during the Northeast Pacific blocking regime.

2-B-4.4 11:45-12:00

Evidence of Association of the AO/NAO with the SST Anomaly in the Tropical Pacific

***Hai Lin**, Gilbert Brunet, Jacques Derome*
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Analysis of the SST data shows that on either interannual or lower frequency time scales, a positive phase of the AO/NAO is associated with a negative SST anomaly in the central tropical Pacific. A SVD analysis was conducted on the Northern Hemisphere winter seasonal mean sea level pressure (SLP) and the tropical Pacific sea surface temperature (SST). The second pair of SVD explains about 26% of the total covariance. The SLP distribution is found to be very similar to a NAO/AO pattern, and the SST component has a negative anomaly associated with a positive phase of NAO/AO pattern.

The GEM model was used to investigate the atmospheric response to a tropical Pacific SST anomaly that has the same distribution as the SST component of the second SVD pair. Preliminary result shows that the atmospheric response to such a SST anomaly pattern is indeed similar to the NAO/AO.

2-B-5.1 10:30-10:45

Effects of Turbulence on Cloud Droplet Collision Rates

Charmaine N Franklin[1], *Paul A Vaillancourt*[2], *MK Yau*[1], *Peter Bartello*[1]
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The time of transition from cloud droplet growth by condensation to that of effective collision and coalescence is an outstanding issue in cloud physics. Turbulence has long been postulated to accelerate the growth of droplets in the size range of 10 to 30 microns in radius. Due to the complexity of the problem, previous studies of turbulence-droplet interactions have made numerous approximations about the flow field and the motion of the droplets, and as a consequence there is a large discrepancy between the results. With the increase in computational power, we are now in a position to be able to use direct numerical simulations of the flow field rather than rely on statistical techniques to investigate the effect of turbulence on the collision rates of droplets.

This study examines the geometric collision rates and collision efficiencies due to hydrodynamic interactions of cloud droplets in evolving isotropic turbulence. The turbulent flow was simulated by direct numerical integration of the Navier-Stokes equations. The model has been used to generate the collision statistics for droplets of radius 10 and 20 microns at several flow Reynolds numbers. The droplet positions, velocities and collision rates have been found to depend on the eddy dissipation rate of turbulent kinetic energy and the characteristic Kolmogorov velocity and time microscales.

The pair correlation function, which is a measure of the preferential concentration of droplets, increases with eddy dissipation rate. When droplets are clustered there is an increased probability of finding two droplets closely separated, thus there is an increase in the collision kernel. For the flow fields explored in this study, the clustering effect accounts for an increase in the collision kernel of 0 – 43%, as compared to the gravitational collision kernel. The spherical collision kernel is also a function of the radial relative velocities amongst droplets and these velocities increase from 1.1 – 2.3 times the corresponding gravitational value. Consequently the geometric collision kernel in the turbulent flows considered is greater than the gravitational kernel by approximately 1.08 to 3.3 times.

Including the hydrodynamic forcing between two interacting droplets through the use of the superposition method resulted in an increase in the collision efficiency of up to 3.5 times the gravitational case. These results assume the flow fields to be fixed over the time of interaction and sensitivity studies show how the efficiency decreases with increasing interaction times. For an eddy dissipation rate of about 100 cm^2 s-3 the collision kernel with the hydrodynamic forcing is about twice the magnitude of the gravitational value, while for an eddy dissipation rate of 1500 cm^2 s-3 this increases to about 9 times. Therefore, these results demonstrate that turbulence could play an important role in the broadening and evolution of the droplet size distribution and the onset of precipitation. Results will also be presented for the hydrodynamic forcing between droplets while the flow is evolving in time throughout the period of interaction.

2-B-5.2 10:45-11:00

A Microphysics Parameterization Scheme for Radar Data Assimilation

Stéphane Laroche[1], *Wanda Szyrmer*[2], *Isztar Zawadzki*[2]
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A growing number of modelling and observational studies point out the importance of an accurate representation of the cloud and precipitation microphysics in atmospheric numerical models. The microphysical calculations, describing the evolution of the spectra of different types of hydrometeors, on the one hand, determine the integral latent heat exchange that has an impact on the dynamics, and on the other hand, allow interpretation of measurements of radar or other remote sensing instruments, either ground-borne or space-borne, and the effective assimilation of these measurements into numerical models. The major unresolved question is what degree of the complexity of microphysical module is required to optimize the combination of the results of observations and numerical models, taking advantage of their continually increasing resolutions.

Due to a great complexity of the microphysical interactions, the hydrometeor spectra are generally characterized in terms of a few bulk quantities that represent the distribution moments or their combination, that substitute the spectral parameters. In the commonly used one- and double moment bulk microphysics schemes, the number of prognostic moments is not sufficient to include the evolution of the shape/curvature of the hydrometeor distribution. Ignoring the variability, sometimes drastic, of the spectrum shape may lead to important errors in the microphysical calculations. This is responsible, among others, for frequently large differences between the model results and radar observations. The use of the normalization approach may, to some degree, reduce the dependence on the shape. But, the results may be much improved by adding one additional predictive moment.

In this paper we present a three-moment scheme that largely eliminates the errors resulting from the assumption of the fixed distribution curvature as in one- and two-moment schemes, and thus, assures more accurate radar reflectivity description in the data assimilation context. Effectiveness of the different schemes is first tested on sedimentation and evaporation processes.

2-B-5.3 11:00-11:15

Numerical Simulation of a Hailstorm using a Triple-Moment Bulk Microphysics Scheme in a Mesoscale Model

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With continuously increasing computer power and a corresponding decrease in the grid-spacing of atmospheric models, grid-scale condensation schemes are playing an increasingly important role in operational NWP. Many explicit microphysics schemes use a Kessler-type parameterization in which one moment of the hydrometeor size distribution – proportional to the total mass concentration – is predicted. More recently, the two-moment method has been used in which both the mass and the total number concentrations of the hydrometeor categories are independently predicted, thereby allowing greater flexibility in the prediction of the size distributions.

The size spectrum of each hydrometeor category is often described by a three-parameter gamma distribution function. Two-moment bulk microphysics schemes generally treat two of the parameters as prognostic while holding the third parameter constant. In this study, the role of the shape parameter is investigated and its effects on sedimentation and microphysical growth rates are examined. Comparisons are made between various bulk parameterizations – a one-moment, a two-moment, and a three-moment scheme – and an analytic bin model. It is found that the shape parameter plays in important role in the overall prediction of hydrometeor mass by affecting both instantaneous microphysical growth rates and changes to the vertical hydrometeor distributions due to sedimentation.

A six-hydrometeor-category double-moment microphysics scheme has been developed at McGill University. In view of the importance of the shape parameter, we have introduced a diagnostic relation for the shape parameter based on the mass-weighted mean diameter. The scheme has also been extended to predict a third moment for each of the sedimenting hydrometeor species, thereby allowing all three size distribution parameters (for most of the categories) to be predicted independently. Both the double-moment and triple-moment versions of the microphysics scheme have been interfaced with the MC2 mesoscale model and used to conduct high-resolution (1 km) simulations of a severe hailstorm. Simulations of the 14 July 2000 Pine Lake supercell, using various versions of the scheme, will be presented and compared. The treatment of the shape parameter in the model ultimately has an important affect on the partition between the solid and liquid precipitation rates of the storm.

2-B-5.4 11:15-11:30

High-Resolution Numerical Simulation of Convective Roll Clouds Associated with High Latitude Cold Air Outbreaks

Anthony Q Liu[1], *Kent GW Moore*[1], *Kazuhisa Tusboki*[2], *Ian A Renfrew*[3]
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[2]Nagoya University, Japan
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Horizontal convective roll clouds are one of the most important forms of boundary layer convection, which often occur over the high latitude ocean during cold air outbreaks. We will present numerical simulations of these roll clouds that have been performed with a 3D cloud-resolving model developed at Nagoya University. Three-dimensional simulations were performed at very high spatial resolutions (~500 m in the horizontal and ~25 m in the vertical) in a domain of sufficient size so as to allow for the development of multiple cloud bands. Many interesting properties of these rolls and detailed structures of secondary flow associated with horizontal rolls were captured by the high-resolution model. The model results indicate that second flow results in significant difference in the temperature, humidity and momentum fields between updrafts and downdrafts of the rolls. The heat and moisture fluxes are stronger in updrafts, which make them warmer and moister. Intense precipitation is observed to occur in the updrafts. The model also successfully reproduced the convective rolls changing into closed cell convection downstream as the vertical shear of zonal wind decreasing. The roll clouds in the model are in good agreement with field observations, which indicates that CReSS is capable of simulating the development of horizontal roll convection associated with high latitude cold air outbreaks. Parallel computing is essentially important for this type of high-resolution large-domain simulations.

2-B-5.5 11:30-11:45

Winter Precipitation Formation and its Impact on Visibility

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Winter storms produce major problems for society and their precipitation is often the key factor responsible. Forecasting winter precipitation is still very difficult because the amount as well as the type have to be determined. The objective of this study is to better understand the formation of winter precipitation within the varying, and interacting, environmental conditions experienced within many winter storms.

A one dimensional cloud model utilizing a double moment microphysics scheme has been developed to address this issue. It predicts the condensate mass content and size distribution for all hydrometeor categories: cloud droplets, rain, snow, ice, graupel, ice pellets and semi-melted snowflakes. The semi-melted snowflakes category is divided into low and high liquid fraction. Temperature and moisture profiles favourable for the formation of different winter precipitation types were varied in a systematic manner in an environment in which snow (accreted or not) is falling continuously from above a temperature inversion.

The results illustrated the detailed evolution of precipitation, as well as that of its environment through heat and moisture exchanges, in the column as well as at the surface. Particular attention was paid to determining and understanding the precise conditions leading to extremes such as the maximum amount, the most rapid change in, and the longest duration of freezing rain, ice pellets or semi-melted particles. In addition, detailed visibility calculations were made to determine the conditions leading to the lowest and greatest values of this parameter as well as to those leading to the most rapid changes. Collectively, this study is the first to carry out a systematic examination of the formation of winter precipitation types, as well as the associated visibility, and to examine the development of extreme conditions in particular.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00

**complete abstracts cited under Poster Session, pp. 167-178*

P-12 (2-B-5)
The Parameterization of Ice Crystals' Heterogeneous Nucleation in Climate Models: Comparison with Observation Taken during SHEBA. ***Daniel Figueras-Nieto****, Eric Girard, Lucia Craciun* (Université du Québec à Montréal, Département des Sciences de la Terre et de l'Atmosphère, Montréal, QC, Canada)

P-13 (2-B-5)
Study of Mixed-Phase Clouds Structure with the Canadian Regional Climate Model. ***Cristina Stefanof***[1], *Alexandru Stefanof*[1], *Alain Beaulne*[2], *Rodrigo Munoz Alpizar*[1], *Wanda Szyrmer*[3], *Jean-Pierre Blanchet*[1] ([1]University of Québec at Montréal, Department of Earth and Atmospheric Sciences, Montréal, QC, Canada; [2]Canadian Meteorological Centre, Dorval, QC, Canada; [3]Department of Atmospheric and Oceanic Sciences, University of McGill, Montréal, QC, Canada)

2-C-1.1 14:00-14:15

An Update on "TAFtime/Thermobot": Experience in Forecast Operations

Steven Laroche, *Alister Ling, Steve Knott, Bruno Larochelle, Steve Ricketts*
Environment Canada, Canadian Meteorological Aviation Centre–West, Edmonton, AB, Canada
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Environment Canada's "Canadian Meteorological Aviation Centre–West" in Edmonton has developed 2 prototype systems to help in meeting the demands in forecast operations. The first system is "ThermoBot" - a set of thermodynamic routines which analyses and displays the atmospheric stability over a large domain based on nwp output. Second is "TAFtime" - a compilation of critical forecast parameters specifically design to assist in the writing of an aerodrome forecast. The web-based products assist the forecaster by efficiently displaying areas that have the potential for hazardous weather (summer convection, wind shear, fog). The forecasters can then focus their efforts and reduce incidents of missed events. Both products are derived from post-processed hi-resolution nwp site forecasts and have been "on-line" for over 1 year. The MSC aviation weather centres in Edmonton and Montréal now make significant use of both prototypes. Although the presentation will outline the basic principles behind the products, the focus will be on discussing their potential value in forecast operations.

2-C-1.2 14:15-14:30

Application of a Radiation Fog Technique to Canadian Aviation Weather Forecasts

Mervyn Jamieson
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Flight delays and cancellations due to significant reductions in visibility due to fog can cause significant disruptions to the Canadian Air Navigation system. These disruptions highlight the need for accurate and timely forecasts of the occurrence, onset and dissipation of fog. Subjective techniques such as pattern recognition, rules of thumb, climatology and gut feelings have traditionally been used by operational aviation weather forecasters with limited skill and success. In an effort to improve the forecast of fog in aviation forecasts, a technique developed by United Parcel Service Airline meteorologists for objectively forecasting radiation fog is being used on an experimental basis by meteorologists from the Meteorological Service of Canada. A description of the technique and preliminary results from its application to forecasts for airports in western and northern Canada will be discussed.

2-C-1.3 14:30-14:45

Nowcasting Airport Winter Weather: First Results from AIRS 2

George A Isaac, *Stewart Cober, Norman Donaldson, Ismail Gultepe, Norbert Driedger, David Hudak*
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The Alliance Icing Research Study II (AIRS 2) was conducted from 3 November 2003 to 12 February 2004. It involved flying research aircraft (5 of them) over a network of ground in-situ and remote-sensing meteorological instruments located at Mirabel, Québec. The main purpose of the study was to develop a Nowcasting system to be used at airports to forecast snow amounts and in-flight icing, which are hazards to aviation. Systems from MSC, NASA and NOAA/NCAR were

on-site at Mirabel. The MSC version of such a system is called the Airport Vicinity Icing and Snow Advisor (AVISA). The main ground based instruments for AVISA included a scanning operational radar, a vertically pointing radar, a microwave radiometer, a ceilometer, and precipitation type and rate gauges. The system also used GOES satellite data, PIREPS, and numerical forecast model output. The ground site at Mirabel was operated continuously during the period, which covered many different types of weather. The aircraft were used to validate the forecasts of in-flight icing produced during the project, and to help understand the physics of winter storms. This talk will present some early results from the experiment, with emphasis on the AVISA system, showing the strengths and weakness of individual sensors and models to predict airport winter weather. It will also show the benefits of integrating data from many different sources to predict the same variables.

2-C-1.4 14:45-15:00

Heads up TAF Alerting - A First Step

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With today's higher weather centre workload and a larger area of responsibility, forecasters require smarter tools to help them manage incoming information. Currently in the MSC (Meteorological Service of Canada) forecasters have tools which alert them when a TAF (Terminal Forecast) does not agree with the current observation and thus an amendment is required. Presented is a first attempt to create a tool which can monitor TAFs for problems in the future if the current observations persist. This tool provides a heads up TAF alert to help warn forecasters of possible problems and encourage more proactive amendments which users would like to see. The current method uses persistence forecasting to evaluate current observations against the short-term forecast provided by the TAF. There will also be discussion on the future potential for extending heads-up TAF alerting techniques to work with model data and monitoring TAFs for improved utility to the user.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00

**complete abstracts cited under Poster Session, pp. 167-178*

P-14 (2-C-1)

Aviation Meteorology – an Operational Approach to Forecasting Low Level Wind Shear.

David B Whittle (Meteorological Service of Canada (MSC), Prairie and Northern Region, Canadian Meteorological Aviation Centre–West, Edmonton, AB, Canada)

2-C-2.1 14:00-14:15

Three Dimensional Intercomparison of Canadian Weather Radars

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The comparison of measurements from neighbouring radars in the Canadian weather radar network can be used to monitor the performance of the radars. Discrepancies between radars often originate in calibration differences, but vertical sampling effects also contribute. In the presence of vertical gradients even small differences in antenna elevation angles can cause differences in radar data that are nominally from the same height. Differences in radar beam widths also effect relative radar measurements. Because radars in the Canadian radar network have relatively narrow beam widths and use multiple elevation angles, three dimensional structure of observed reflectivity can be used to assess differences between radar. For example, the normally flat bright band will appear curved if an antenna system is pointing higher or lower than it reports.

A technique built on work in the Finnish Met. Institute can be used to separate and estimate the elevation and electronic calibration differences. The FMI technique has been seen to work well in some situations and not in others, but the reasons for the variable performance were not clearly understood. Simulations of the radar observation system have been developed to show how this technique can be expected to work for different radar configurations and different weather situations. Applying these techniques to the Canadian network has shown that some radars are consistently different from their neighbours, confirming assessments made by other means. While the techniques only provide relative errors, trends can be used to identify radars that are suffering from progressive failures.

2-C-2.2 14:15-14:30

The Effect of the Degree of Common Orientation of the Hydrometeors on Polarimetric Radar Observables

Ana Berbeleac, ***Enrico Torlaschi***
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We examine a polarimetric weather radar transmitting simultaneously horizontal (H) and vertical (V) polarized radiation without pulse train switching between orthogonal states. For simultaneous reception of both complex signal amplitudes at H and V polarization the radar observables representing the radar signal from an ensemble of particles filling a radar resolution volume are reflectivity, ZH, differential reflectivity, ZDR, copolar correlation coefficient at zero lag time, rhoHV, and total differential propagation phase shift, PHI = phiDP + delta, where phiDP is the differential propagation phase shift, and delta is the backscattering differential phase shift. Of primary interest for precipitation measurements is the calculation of the specific differential phase KDP (which is the slope of phiDP with range), since it is a better estimator of precipitation at high rain rates than reflectivity alone. Because phiDP is range cumulative the negative values of KDP, which are frequently observed, are attributed to the backscattering phase. However, recently it has been shown theoretically that part of the range variation of PHI could be due to the variation of the degree of common orientation of the hydrometeors when the radar beam moves from a region of well oriented particles to a region of less oriented ones.

Data already published in the literature and from the McGill polarimetric operational S-band radar are presented. Range profiles crossing the melting layer, and a hail shaft are examined. It will be shown that the negative values of KDP are not only a consequence of the backscattering phase shift but of the variation of the degree of common orientation of the hydrometeors as well.

2-C-2.3 14:30-14:45

A Comparison of the Radar Decision Support System and Unified Radar Processor in the Analysis of Two Severe Weather Events on the Prairies

Derrick Kania, *Patrick McCaarthy, Mike McDonald, Dave Patrick*
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Radar Decision Support System (RDSS) and Unified Radar Processor (URP) are radar analysis tools utilized by meteorologists of the Meteorological Services of Canada's Prairie Storm Prediction Centre in Winnipeg. These radar tools assist the meteorologists in the diagnosis and analysis of summer severe weather events. RDSS uses volumetric radar data to determine three dimensional storm structure in classifying severe storms. URP incorporates both volumetric radar data and Doppler radar data in combination with a series of algorithms to generate a ranking system of severe storms. A comparison of the output from these two systems is presented, focused on the severe weather events of July 14, 2003 at Gretna, Manitoba and August 12, 2003 near Wabumun, Alberta.

2-C-2.4 14:45-15:00

The Implement of the Background Error Covariance in the Cloud-Scale Radar Data Assimilation Cycles

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McGill cloud-scale radar data assimilation algorithm has been developed for the past decade. A variational method, in which the dynamic core of the MC2 model coupled with the microphysics parameterization of Kessler (1969) used as a weak constraint, is used to retrieve 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. In order to decrease the effect of time tendency in consecutive volume scans of radar data, the CAPPI of the radar data are interpolated into a moving frame of reference. In this study, the quality of the retrieval fields is verified by a 30-min MC2 model forecast starting with the analysis of this algorithm. Radar data are discrete in space and time; moreover they do not fully cover the entire model domain. In our algorithm, 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. Both of the spatial structure of the background error covariance and the smoothness constraint can be used to smooth the radar data and spread out the information of radar observations to data void region. The smoothness constraint is already integrated into our algorithm. In this sturdy, the background error covariance is implemented and its performance is compared with that of the smoothness constraint.

2-C-2.5 15:00-15:15

Description of the Canadian Precipitation Analysis (CaPA) Project

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The Canadian Precipitation Analysis (CaPA) is a project from the High Impact Weather National Laboratory initiative of the Meteorological Service of Canada. This project wants to address the need for accurate Quantitative Precipitation Estimates (QPE) over Canada that is required for various important applications (model verifications, nowcasting, hydrology, data assimilation). In its first definition, the CaPA project intends at generating a real-time precipitation analysis every 6 hours with a horizontal resolution of about 25 km over Canada. The analysis scheme is based on a univariate Optimal Interpolation (OI) using 6h accumulation from the regional model GEM as a background field. The observations to be assimilated are surface rain gauges from the national and cooperative networks, and also radar precipitation estimates from the URP system.

As a first step, a pilot product is currently under development at a higher spatial resolution of about 10 km over the Québec region. The availability of about 300 surface stations over Southern Québec and the radar coverage justifies an increase of horizontal resolution. This pilot project has been proposed to demonstrate the feasibility of this concept, and to highlight the importance of additional surface observations from cooperative network and high quality of radar QPE. Preliminary results are shown for the period of August 2003. The methodology defined for the quality control of radar data is explained and sensitivity experiments to the specification of statistics of forecast and observation errors are presented.

2-C-2.6 15:15-15:30

The BC Wildfires of 2003: Tracers for Detection of Atmospheric Features by Weather Radar and Satellites

Robert Nissen, *Laurie Neil*
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The summer of 2003 was a particularly active year for wildfires in southern British Columbia. Warm and very dry conditions resulted in a number of major fires. Their destructive interaction with communities garnered national attention, but they also affected large areas of the backcountry with major impacts on the regional resource and tourism sectors of the economy. The extensive areas affected in complex terrain are conducive to the use of remote sensing techniques for detection and monitoring of the fires. In contrast to previous summers, the new Mt. Silver Star radar was available and capable of detecting the larger fires in the southern interior of the province. In this presentation we discuss the complementary capabilities of weather radar and satellite imagery to infer various atmospheric features at different spatial scales using wildfire smoke as a tracer. With the recent commencement of operations for the Prince George radar in the central interior of the province we anticipate further enhanced detection and monitoring abilities for the upcoming fire season.

2-C-3.1 14:00-14:15

An Analysis of Freshwater Transport in an Eddy-Permitting Regional Model of the Sub-Polar North Atlantic

Paul G Myers
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The climate of the North Atlantic and the Arctic are linked in a number of ways. Decadal variability in ocean properties, winds, precipitation, etc. have been linked to both the North Atlantic and Arctic oscillations and to each other through feedback loops. A key feature of all these loops is the export of freshwater (both in liquid form and as ice) from the Arctic to the North Atlantic, where it can have a major effect on deep convection. The main export source for this freshwater has been generally considered to be Fram Strait and this is where it is normally applied in global climate models. However, there is also a significant transport of freshwater from the Arctic to the Labrador Sea through the Canadian Archipelago (e.g., 920 km^3/yr^{-1}, Aagaard and Carmack, 1989) but many climate models (and most ocean only models) treat this region as a solid land boundary. The transport of freshwater is analyzed in an eddy-permitting regional model of the sub-polar North Atlantic. This works focuses on the export of freshwater (in liquid form) through Davis Strait. The export from Hudson Strait is shown to be insignificant. The freshwater pathways within the sub-polar gyre are examined. The role of the mean and transient circulations in allowing the freshwater to leak from the boundary currents into the Labrador Sea gyre is considered. The impact of potential changes in the freshwater export from the Arctic (for events ranging from NAO related variability to potential future climate changes) is examined, focusing on Labrador Sea Water formation and dispersal.

2-C-3.2 14:15-14:30

A Regional Eddy-Permitting Ocean Model of the Sub-Polar North Atlantic under Flux Forcing

Duo Yang, *Paul G Myers*
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Experiments to examine oceanic variability and climate system changes in ocean-only models are often more robust when surface flux forcing is used rather than restoring boundary conditions. However, ocean models often behave poorly when forced by fluxes, with significant drifts in temperature and salinity. Here we examine the use of surface flux forcing in a regional eddy-permitting ocean general circulation model of the sub-polar North Atlantic Ocean. Our flux forcing is taken from two different climatologies, from the Southampton Oceanography Center (SOC) and the NCEP-NCAR reanalysis. The former reflects a comprehensive set of ship/buoy observations based on a short time period, 1980~1993, coincident with a high North Atlantic Oscillation (NAO) phase. The latter is based on a long time series (1948~1998), and some studies show that it may overestimate heat loss (Josey, 2001). We also crudely parameterize the effect of high-frequency variability resulting from the passages of synoptic scale events on the heat flux over the convective region of the Labrador Sea during winter months, due to its role in triggering deep convection. With the use of a weak restoring term on salinity (to parameterize non-represented sea ice processes), the model remains stable and all major features of the sub-polar gyre are represented. Sub-polar mode water formation and dispersal are improved with respect to an equivalent run with restoring conditions. Improvements are also seen in the model eddy kinetic

energy fields. The structure of the surface fluxes leads to potentially unrealistic deep convection in the Irminger Sea, with this situation exacerbated with the hydrographically corrected SOC fluxes. Decadal variability associated with 'deep' convection in the eastern basin and changes in the path of North Atlantic Current is observed in one experiment. A drift in temperature and salinity, seen in most high-resolution models of the sub-polar gyre, is observed, although it appears to be dominated by internal advection processes rather than surface forcing. Ongoing work is examining the model under variable forcing related to the NAO.

2-C-3.3 14:30-14:45

Sensitivity of an Eddy-Permitting Ocean Model to Different Parameterizations for Tracer Mixing

Daniel Deacu, *Paul G Myers*
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Two slightly different implementations of a variable eddy transfer coefficient have been tested in a 1/3°-resolution ocean model of the subpolar North Atlantic. Basin-averaged values of the kinetic energy of the mean flow and eddy kinetic energy show a more energetic but less time-variable flow when the variable transfer coefficient is used. The reduced variability is a result of a larger release of available potential energy by means of the Gent-McWilliams eddy-induced velocity in regions susceptible to baroclinic instability. Less energetic baroclinic eddies occur along the Labrador continental slope, and this leads to the simulation of a weaker and more realistic counter-current, seaward of the Labrador Current. This has positive effects on the circulation along the slope as well as on the hydrographic properties in the Labrador Sea. The relative strength of the slope branch of the Labrador Current with respect to the shelf branch is increased and the Deep Western Boundary Current core becomes more clearly identifiable. Time series of freshwater and heat content for the Labrador sea indicate a better preservation of these properties in time, with respect to a previous experiment with a constant eddy transfer coefficient, due mainly to a reduced import of warm and salty water of North Atlantic Current origin into the Labrador Sea. The improved spreading of tracers along isopycnal surfaces, especially across the frontal regions demonstrate the positive effect of tracer advection by the bolus velocity combined with a low level of spurious mixing obtained by a very large reduction in the background lateral diffusion.

2-C-3.4 14:45-15:00

Seasonal Circulation variability over the Newfoundland Shelf and Slope

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Monthly-mean circulation fields over the Newfoundland Shelf and Slope are simulated using a 3-D hydrodynamic model. The model is forced by climatological monthly-mean wind stress and density fields. The open boundary condition accounts for the effects of the large-scale wind forcing, steric height and additional barotropic inflow. The model solutions indicate equatorward shelf-edge and nearshore flows, which are strong in fall/winter and weak in spring/summer. The model results are in agreement with moored observations.

2-C-3.5 15:00-15:15

Toward a Regional Operational Model for the Newfoundland Shelf

Fraser JM Davidson
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Under collaboration with MERSEA we are looking to develop a regional operational ocean forecasting system for the Newfoundland Shelf and adjacent deeper waters over 5 years. The system will involve an operational network as well as a modelling system. The regional model will be 1 way nested within the MERCATOR PSY2 operational basin scale model. The observation network includes sea surface temperature images, HF-Radar derived currents (obtained from department of National Defence), satellite linked CTD tags deployed on Harp Seals, ships of opportunity, regular oceanographic surveys (23 a year) as well as moorings. Eventual use of satellite altimetry is also being considered. The operational observation network is mostly based on upgrading present observation systems to transmit in real time to a central data base.

The talk will cover the development plan to operational status as well as describing the benefits of such a model and observation system for the Newfoundland Shelf (oil industry, fishery, ice prediction) Targeted horizontal model resolution is 3 km and then 2 km. In addition to an overview of the project and current efforts, preliminary results of temperature profiles from Seal based profiling tags will be presented.

2-C-3.6 15:15-15:30

Resolution Issues in Numerical Circulation Models

David A Greenberg
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Modelling the ocean will always involve compromises of scale. Even with increases in computation speed and available memory, any model is subject to practical limits on its resolution. Increasing resolution adds to computer storage space and computation time. The time increase is not only due to increased computation points but decreasing time step requirements of stability criteria. Regional models face the added complications of assumptions imposed on open boundaries that are hopefully "small enough" and "far enough away" not to impact on the solution in the area of interest. In practice, the scales important to an accurate solution of a problem are rarely uniform over the domain of a model. Changes in topography and coastline over small scales can have a critical influence over processes throughout a domain. Baroclinic and barotropic properties vary on many scales determined by many factors such as meteorology and the Earth's rotation.

This presentation looks at factors leading to varying physical scales and highlights problems that might be better resolved by targeting model spatial resolution to the variation in these scales.

2-C-4.1

14:00-14:30
Invited

Development of Canadian Regional Climate Model v.4

Rene Laprise[1], *Daniel Caya*[1], **Laxmi Sushama**[1], *Arturo Quintanar*[1], *Minwei Qian*[1], *Sebastian Biner*[2]
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Development of Version 4.0 of the Canadian Regional Climate model (CRCM) is in progress at UQAM and at Ouranos. CRCM's sub-grid scale physical parameterization uses the Canadian GCMiii (General Circulation Model Version III) package, which was adapted to the regional model's grid and projection. Version 4 of the model has the three-layer physically based land-surface scheme CLASS.

This paper will review some of the developments underway such as (1) coupling of CRCM with a Regional Ocean Model (ROM) (2) implementation of a river routing scheme (3) sensitivity tests to anomalous forcing and (4) representation of cold region processes along with some results from a beta version of the model developed by the Climate Research Branch at Downsview and Victoria.

2-C-4.2

14:30-14:45

Comparison of Simulation by two Regional Atmospheric Models over the Mackenzie River Basin

Iriola Mati[1], *Charles Lin*[1], *Lei Wen*[1], *Olivier Bousquet*[1], *Kit Szeto*[2], *Murray D MacKay*[2]
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Results from two regional atmospheric models (Canadian Regional Climate Model, CRCM; Mesoscale Compressible Community Model, MC2) are inter-compared to assess the effects of using GCM-type model physics in mesoscale regional climate simulations with the CRCM. The two models are coupled to the same Canadian Land Surface Scheme (CLASS). They are driven at the lateral boundaries using CMC (Canadian Meteorological Centre) analysis fields.

A case study approach is used. Wavelet scale decomposition and conventional statistical methods are used to compare different variables from the two models, such as temperature, geopotential height, specific humidity and relative vorticity. There is good agreement between the two models. Various biases exist when the model results are compared to CMC analysis. The underestimation of power spectra for both models compared to CMC analysis is more obvious at smaller scales.

2-C-4.3 14:45-15:00

MC2 Simulations of the Interaction of Airflow with the Western Cordillera during Extreme Winter Temperature Events over the Mackenzie River Basin

Kit Szeto[1], *Peter Yau*[2]
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Results from the Mackenzie GEWEX Study (MAGS) suggest that the interaction of the low-level airflow into the Mackenzie River Basin with the Western Cordillera exerts first order effects in determining the cold season atmospheric thermal response of the basin to changes in the large-scale circulation. In this study, interactions of the airflow with the mountainous terrain located to the west of the basin during recent extreme winter temperature events that occurred in the basin are studied with the MC2 model. In addition, numerical sensitivity experiments are performed to examine the main physical and numerical factors that affect the interactions as well as their subsequent impacts on the development of extreme temperature events in the model. Implications of the results in the future improvement of numerical predictions of these extreme events and the interannual variability of winter temperatures in the basin will also be discussed.

2-C-4.4 15:00-15:15

Teleconnections, 1000-500 hPa Thickness and Storm Tracks in the Northern Hemisphere

Anantha Aiyyer, ***Eyad Atallah***, *Lance Bosart*
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The North Atlantic Oscillation (NAO) and the Pacific/North American (PNA) pattern are important modes of low-frequency variability of the atmosphere in the Northern Hemisphere. In this study, climatologies of the 1000-500 hPa Thickness and 500 hPa Storm Tracks will be examined in relation to the phase of the NAO and PNA patterns. Data from the National Centers for Environmental Prediction (NCEP)/National Center for Atmospheric Research (NCAR) Reanalysis are used. The NAO and PNA indices are constructed using daily mean height fields at the 500 hPa level. The 1000-500 hPa thickness is computed twice daily. The storm tracks are also created using twice daily height fields through an objective method that identifies closed lows on the 500 hPa level.

Preliminary results indicate that transitions in the PNA and NAO patterns are often preceded by pattern amplification. With respect to the NAO, transition often occurs as a result of retrogression of the main height anomaly originally situated over Greenland. In contrast, PNA transition from positive to negative tends to occur as a result of a progression of height anomalies across the Pacific, while PNA transition form negative to positive often occurs as a result of a retrogression of the low height anomaly situated along the west coast of Canada. During the negative phase of the NAO, the North Atlantic storm track is displaced to the south. Meanwhile, a positive PNA pattern results in a corridor of increased cyclonic activity running from the southwestern United States to the Maritime Provinces of Canada.

2-C-4.5 15:15-15:30

Variability of the Bulk Heat Exchange of Great Slave Lake

William M Schertzer[1], *Wayne R Rouse*[2], *Peter D Blanken*[3], *Anne E Walker*[4]
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An important objective within the Global Energy and Water Cycle Experiment on the Mackenzie Basin (GEWEX-MAGS) is to understand the role of lakes within the northern climate system. Great Slave Lake represents the fifth largest lake in North America (surface area = 27,200 km^2; volume = 1070 km^3) and has been the focus of both intensive field measurements and modelling to describe the variability of the heat and mass exchange. Daily time-series of cross-lake in situ temperatures in 1998-2002 are applied to a 2 x 2 km grid bathymetry to derive annual cycles of daily temperature and heat content. Over the 5-year period, maximum surface temperatures ranged between 14.0 to 21.2 C and maximum heat content ranged from 2.13E19 J to 2.6E19 J. Highest values were associated with an intense El Nino in 1998 resulting in a longer ice-free period allowing effective lake heating compared to other years. 5-day mean bulk heat exchange (dH) was computed based on the daily lake heat content. Average dH from 1998 to 2002 ranges from 267 W/m^2 in spring to -338 W/m^2 in fall. Heat exchange derived from the lake temperature-heat content approach compare favourably with observations from an island platform in the central basin. Results illustrate the sensitivity of large deep northern lakes to climatic variability.

2-C-5.1 14:00-14:30 Invited

A Drought Reporting System for Agriculture in Alberta

Allan E Howard[1], *Samuel SP Shen*[2], *Ralph Wright*[1], *Sean McGinn*[3], *Anita Shepherd*[3]
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A system was developed to report drought conditions in near real-time for the agricultural area of Alberta. The main goal of the project was to improve the spatial and temporal evaluation of drought extent, severity and location using science-based drought indices. Drought support programs will be activated on the basis of the drought evaluation using this system. The system uses weather, crop and soil data to model a series of drought indices in near real time that identify seasonal and hydrologic drought conditions that could impact agriculture. The model is a version of the Versatile Soil Moisture Budget modified by Akinremi et al. (1996), which was further modified to run at a 10 km scale to meet the needs of the drought reporting system. To enhance the interpretation of the drought indices, historic data for Alberta and the surrounding area was interpolated to develop a dataset with daily weather values from 1901-2002 on polygons at three scales, the Ecodistrict, the Soil Landscapes of Canada (SLC), and a 10 km grid. The interpolation was based on the methods of Shen et al. (2001). The data at the 10 km scale has been used to model 100-year and 30-year normal soil moisture conditions and precipitation patterns for the agricultural area of Alberta. The 30-year normals form the basis for several drought indices used in the Alberta drought monitoring system. The dataset is also being analyzed to develop probable scenarios for weather inputs as anticipated future drought movements are modelled up to 6 months in advance.

2-C-5.2 14:30-14:45

Observed Changes of Cyclone Activities in Canada

Hui Wan, *Xiaolan L Wang*, *Val R Swail*
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This study aims to assess the climate and trends of cyclone activities in Canada. Since strong cyclones or severe storms are usually associated with large 3-hourly pressure changes, the data base for this study is 3-hourly pressure changes calculated from hourly pressure data observed at 83 Canadian stations for the period from 1953 to 2002. A site is said to be affected by cyclone activity when the sea level pressure at that site is bellow 1000 hPa. In the presence of a cyclone, the magnitude of 3-hourly pressure changes (fall/rise) reflects the intensity of cyclone activity, and the number of pressure changes exceeding an extreme magnitude corresponds to the number of severe storms. We carried out the difference of means test (t-test) to check if there has been any change in the average numbers of cyclones for two successive 25-year periods: 1953-1977 and 1978-2002. The results show that, over the past 50 years, the number of winter (JFM) cyclones has increased significantly in eastern Canada, and decreased in western and northern Canada; while the number of fall (OND) cyclones has increased in southern Canada, and decreased in the north.

We also performed the Kolmogorov-Smirnoff (K-S) test to determine whether there has been any change in the probability distribution of 3-hourly pressure fall/rise associated with cyclone activities. The results show significant distributional changes in the past half century: In winter, the distribution has become wider (longer-tailed) in northern Canada and narrower (shorter-tailed)

in the south. In fall, it has become narrower everywhere, except Ontario and the west coast where it has become wider. Note that a wider and longer-tailed (narrower and shorter tailed) distribution indicates increased (decreased) frequency of extreme events. Changes in the seasonal maxima of 3-hourly pressure fall/rise were also assessed by means of non-stationary Generalized Extreme Value (GEV) analysis. The results of this GEV analysis corroborate those from the K-S test: In winter, extreme cyclone activities have become more frequent in northern Canada, and less frequent in southern Canada.

2-C-5.3 14:45-15:00

Assessment of Observational Biases and Trends in Canadian Cloudiness

Xiaolan L Wang[1], *Francis W Zwiers*[1], *Val R Swail*[1], *Ted Yuzyk*[2]
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We have analyzed the hourly cloudiness record (in tenths of the sky dome) at 103 Canadian stations where observations were made by human observers. The records at 56 stations span the period from January 1953 to April 2003, while the remaining 47 stations have shorter (35-49 years) records. All records are nearly complete. Our assessment of cloudiness trends, by means of logistic regression, was preceded by an intensive assessment of observational biases. This assessment involved statistical change-point analysis, station metadata investigation and visual inspection of the time series in question. Changes in observing practices and observer training, frequent observer changes, relocation, etc. were found to introduce significant step-changes in cloudiness time series, especially in the period before the latest version of Canadian Manual of Surface Weather Observations (MANOBS) was published in January 1977. We carried out the analyses for each of the 11 cloudiness conditions (from clear sky to overcast: 0/10 - 10/10) separately, while preserving consistency among the 11 categories. The results of our analyses show that observational biases in Canadian cloudiness records are too numerous and too significant to ignore. Trends estimated from unadjusted cloudiness data could be far way from the reality. After removing the effect of observational biases, the overall trends of Canadian cloudiness features more frequent occurrence of clear sky, nearly overcast (9/10) and overcast conditions, and less frequent occurrence of broken sky conditions in daytime; while in nighttime it features more frequent medium-heavy cloudiness conditions and less frequent clear sky and light (1-2 tenths) cloudiness. The overall nighttime cloudiness has increased in the past half century, which blocks the out-going long wave radiation and contributes to the strong increase in daily minimum temperature in Canada.

2-C-5.4 15:00-15:15

Temporal and Spatial Changes of the Agroclimate in Alberta from 1901-2002

Huamei Yin[1], *Samuel SP Shen*[1], *Karen Cannon*[2], *Allan Howard*[2], *Shane Chetner*[2], *Thomas R Karl*[3]
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This paper analyzes the long-term (1901-2002) temporal trends in the agroclimate of Alberta and explores the spatial variations of the agroclimatic resources and the potential crop-growing area in Alberta. Nine agroclimatic parameters are investigated: May-August precipitation, start of

growing season, end of growing season, length of growing season, date of last spring frost (LSF), date of first fall frost (FFF), length of frost-free period (FFP), growing degree days, and corn heat units. The temporal trends in the agroclimatic parameters are analyzed by using linear regression. The significance tests of the trends are made by using Kendall's Tau method. The results support the following conclusions:

(i) The May-August precipitation has increased all over the province, with larger amplitude in the northern part of the province.
(ii) No significant long-term trends are found for the start, end, and length of the growing season.
(iii) An earlier LSF, a later FFF, and a longer FFP are obvious all over the province; this trend reduces the risk of frost damages to crops. The change in the LSF and FFF is asymmetric.
(iv) The area suitable for corn planting has extended to the north by about 200-300 km compared to the 1910s, and by about 50-100 km compared to the 1940s; this expansion implies that more species of crop can be grown in Alberta than could be previously.

The total precipitation follows a similar increasing trend to that of the May-August precipitation and the percentile analysis of precipitation attributes the increase to low-intensity events. The Alberta drought records do not show a discernable trend of drought events, when excluding the extreme dry period from 1999-2002. Therefore, Alberta agriculture has benefited from the last century's climate change.

2-C-5.5 15:15-15:30
Calibration of Dynamical Seasonal Prediction with Ensemble Principal Component Regression

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A popular modern approach to prediction of seasonal-mean atmospheric anomalies is to make use of ensemble integrations of state-of-the-art general circulation models (GCMs). Such dynamical seasonal prediction (DSP)is bound to include a considerable component of systematic error induced by the deficiency of GCMs and the chaotic nature of atmospheric internal dynamics. A principal component regression (PCR) scheme targeting on these unpredictable noises in the DSP ensembles is presented in this study. The scheme consists of applying PCR to a number of bootstrapping ensemble series rather than to the solo ensemble-mean series; the resulting regression ensembles can then be averaged to form the final prediction. It is demonstrated in an application that the post-PCR ensemble averaging can effectively filter out not only the surviving systematic errors, but also the sampling and computational noises resulting from the PCR operation. As a result, the ensemble PCR scheme is found more skillful, and easier to apply, than a scheme proposed in a previous study (Mo and Straus, *Mon. Wea. Rev.*, 2167-2187, 2002) that applies PCR to the ensemble-mean series with a cross-validated screening procedure. Another advantage of the ensemble PCR scheme over the ensemble-mean PCR scheme is that it allows the final prediction to be delivered and verified in a probabilistic framework. It is shown that the probabilistic prediction based on the calibrated ensembles is more skillful and reliable than that based on the raw DSP ensembles.

2-D-1.1 16:00-16:15

Proposed Research Applications for "POSS"

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In the 1980s the Meteorological Service of Canada developed a small X-band Doppler radar for use on aviation Automated Weather Observing Systems (AWOS) as a precipitation identification sensor. The instrument, called the Precipitation Occurrence Sensor System (POSS), reports minutely the Doppler velocity spectra of precipitation falling within 2 metres of the instrument. From these spectra the raindrop size distribution can be estimated, as well as many derived parameters such as precipitation rate and radar reflectivity. There are currently 95 POSS systems operating at locations across Canada. This represents the largest national network of disdrometers in the world and gives Canada a unique opportunity to develop several applications.

This paper will present potential applications of POSS products in several fields. POSS derived radar reflectivities could be used to calibrate the national radar network. Relationships between radar reflectivity and precipitation rate can be derived from POSS measurements in near real time and used to improve quantitative precipitation estimation in both liquid and frozen precipitation. In another application, high temporal resolution precipitation typing and rates play a critical role in nowcasting of airport icing conditions.

As well, the POSS could play an important role in the Canadian component of the Global Precipitation Mission. This international mission will consist of a constellation of satellites with remote sensors designed to measure global precipitation. POSS products could be used both for ground-truthing satellite estimates of precipitation, and to verify the assumptions on which the models are based to retrieve precipitation estimates from space-borne remote sensors.

2-D-1.2 16:15-16:30

Ground-Based Radiometric Profiling during Dynamic Weather Conditions

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Continuous temperature and humidity soundings up to 10 km height and one-layer cloud liquid soundings can be retrieved from ground-based multi-channel microwave radiometer observations. The accuracy of radiosonde and radiometric temperature and humidity soundings are found to be similar when used for numerical weather prediction. The presentation will include: (1) demonstration of accurate radiometric observations and retrievals during precipitation, fog, boundary layer turbulence, and clear air downburst conditions, (2) short term precipitation forecasting using an azimuthal scan radiometer, and (3) significant forecast improvements obtained by assimilation of precipitable water estimated from ground-based GPS observations. These examples show that microwave remote sensing by multi-channel radiometers and by ground-based GPS receivers has significant potential for a variety of applications in meteorological research and operations.

2-D-1.3 16:30-16:45

Initial Investigation on the Use of Ram Falls SODAR Data for Assessing the Potential for Summer Convection in Alberta

Robert Peirson, *Ron Goodson*
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In this presentation, we report the results from a subjective investigation of the potential utility of data from a SODAR located at Ram Falls, Alberta for operational convective weather forecasting. A dataset covering the summer of 1999 was used, provided by Husky Oil Inc. The horizontal wind field and a turbulence parameter were compared for convective versus non-convective days to determine if there were sufficiently large differences to warrant further study. It was hoped that the location of the Husky SODAR, in the Rocky Mountain foothills, might be well-situated to capture the existence and breakdown of inversions along the Alberta foothills (which are involved in the formation of convective weather over central Alberta). Another aspect explored was to see if there was any signature in the SODAR data that could alert the forecasters to the potential for convection (and its severity). Results from this initial look are, at best, inconclusive. While some differences between convective and non-convective days are noted, they do not appear to be either consistent or substantial enough to be of value for convective forecasting on a day-to-day basis.

2-D-1.4 16:45-17:00

Preliminary Results from a Performance Evaluation of Temperature and Humidity Sensors in the Canadian Climate Network

Gary Beaney, Brian E Sheppard, ***Tomasz Stapf***
Atmospheric Monitoring and Water Survey Directorate, National Weather and Climate Networks, Meteorological Service of Canada (MSC), Downsview, ON, Canada
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Over the past few decades the progressive automation of the Canadian climate network has been undertaken by each of five National Regions (Pacific and Yukon, Prairie and Northern, Ontario, Québec, Atlantic). As a consequence the national climate network is populated with a variety of different sensors installed in a variety of configurations. Although the performance specifications of these sensors may be provided by individual manufacturers, no nationwide field evaluations have been undertaken by the Meteorological Service of Canada.

In an attempt to quantify the uncertainties of temperature and humidity measurement, the Test and Evaluation Division of the Meteorological Service of Canada organized a field evaluation of the majority of temperature and humidity sensor models and configurations currently in use in the Canadian climate network. The field study began in the fall of 2002 at the Centre for Atmospheric Research Experiments (CARE) in Egbert, Ontario. Preliminary results indicate that the type of non-aspirated screen used does not appear to have a significant impact on temperature sensor performance. A high degree of variability was also observed between identical sensors in identical configurations. This paper will expand upon these preliminary results and describe the experimental design used in the evaluation of the temperature and humidity "sensors in use" in the Canadian climate network.

Session 2-D-2

Hazardous Weather IV – Winter Storms

Piesporter Room/salle, Chair/chaise: *Peter Bowyer*

2-D-2.1

16:00-16:15

The Maritime Blizzard of 2004

Carolyne Marshall
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The Blizzard of 2004 brought the Halifax Regional Municipality and most of Nova Scotia and Prince Edward Island to an absolute standstill. The snow began quietly and calmly on the evening of Wednesday February 18th, 2004. The storm developed into a raging frenzy of snow, high winds, blowing snow, and white-out conditions throughout the next 24 to 36 hours as a Nor'Easter ripped across the Maritimes. The result led to two history-making province-wide states of emergency across Nova Scotia and Prince Edward Island as almost 100 cm of snow fell, paralyzing cities and rural areas. Storm surges rose to near record levels along the New Brunswick, Nova Scotia, and Prince Edward Island coastlines resulting in some coastal damage and instituting local evacuations. Schools in Nova Scotia and Prince Edward Island were closed for days. There were three successive nights in which a curfew was instituted in the Halifax Regional Municipality. Cars were completely buried and people stranded for days in the wake of the storm's fury. This presentation will highlight the storm and the impacts to the Maritimes.

2-D-2.2

16:15-16:30

Severe Ice Storm Risks in Ontario

***Joan Klaassen**, Heather Auld, Malcolm Geast, Shouquan Cheng, Ela Ros, Ron Lee*
Meteorological Service of Canada (MSC)-Ontario Region, Environment Canada, Downsview, ON, Canada
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Although ice storms of any duration and magnitude can have serious impacts on critical infrastructure and community planning, those associated with severe ice storms such as the January 1998 Ice Storm can be particularly devastating. Better severe ice storm risk information will allow enhanced emergency planning and disaster prevention in regions or communities identified as more at risk from this hazard. The information will also help communities to identify critical infrastructure and allow better planning and design of this infrastructure to minimize future risks.

In a study undertaken by the Meteorological Service of Canada, various scientific approaches were used to identify those regions and communities in south-central Canada which could be at the highest risk from severe ice storms, and to assess whether these risks could be increasing with winter climate warming. The analysis area focused on the heavily populated and therefore vulnerable area of southern and eastern Ontario, with a population of approximately 10 million or 35% of all Canadians. Ice Storm '98 was compared to 24 other significant ice storms that have affected Ontario since the mid 1800s and another 22 major ice storms since the early 1900s that have impacted the northern U.S. states bordering Ontario.

The study also updated the climatology of average freezing rain conditions in Ontario and examined historical trends in synoptic map types associated with freezing rain conditions of varying durations. The results indicate that the Great Lakes influence the occurrence of freezing rain during some months of the year and at some shoreline locations, and may also act to reduce the risks for severe ice storms.

Finally, a GCM climate change scenario assessment of freezing rain related weather patterns in the future warming climate suggests that there may potentially be an increased risk for severe ice storms in southern and eastern Ontario away from the Great Lakes.

2-D-2.3 16:30-16:45

Lake-Effect Snowstorms over Southern Ontario and their Associated Synoptic-Scale Environment

Anthony Q Liu, *Kent GW Moore*
Physics Department, University of Toronto, ON, Canada
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Lake-effect snowstorms are an important source of severe winter weather over the Great Lakes region and are often triggered by the passage of synoptic-scale low-pressure systems. In this paper, we develop a climatology of lake-effect snowstorms over southern Ontario for the period 1992-1999. The distinguishing characteristics of the synoptic-scale environment associated with intense lake-effect snowstorms in the region are identified through the study of the individual event and through composite analysis. In particular, it is found that a low-pressure and a cold-temperature anomaly situated over Hudson Bay, north of the Great Lakes, is a favourable environment for the development of intense lake-effect snowstorms over southern Ontario. We also find that the track of the low-pressure system can have a significant impact on the development or lack thereof of lake-effect snowstorms over southern Ontario. It is found that the low-pressure systems that trigger intense lake-effect snowstorms tend to have an anomalous northeastward track as compared to eastward track of most low-pressure systems that transit the region.

2-D-2.4 16:45-17:00

A Classification Scheme for High Impact Winter Weather on the Canadian Prairies

Jim Slipec
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Winter is a time of very significant weather across much of Canada and most especially the prairie region. With the Rocky mountain influences to the west, the great plains stretching to the east, and the Arctic region to its north, central Canada is host to a variety of hazardous or high impact events. When considering the most significant type of weather, we think of winter snow storms and more importantly the blizzard. In order to begin to quantify high impact weather, it seems logical to start with the most hazardous phenomena and work from there.

Blizzards affect large areas and often for extended time frames causing not only economic impacts and losses, but also threatening life and limb. Near zero visibility in snow and blowing snow, dangerous wind chills, often damaging winds are all by products of a "typical" blizzard. However with many variables at play, it stands to reason that no two blizzards are exactly the same, nor do they always affect an area in the same way. It should be apparent then, that some form of classification system for this type of storm is warranted. There are some schemes that do exist, but are quite complex in nature. As with the Fujita scale for tornadoes, it seems logical to develop a simple system to categorize blizzards based on the intensity of the weather elements and the impact they have. Putting a given blizzard event into a category (1 to 5 scale) would allow a quick interchange of ideas and lead to better coordination amongst meteorological offices. More

importantly perhaps to the non meteorological sector at large, categorizing blizzards would provide invaluable information on potential impacts to areas such as the transportation sector (trucking, airlines), city and provincial snow clearing crews, the media and the general public at large.

While the meteorological dynamics of the storm are worth consideration, ultimately it is its impact which is of the greatest importance. It is envisioned that such a blizzard classification scheme could one day become part of a broader system of categorizing risk based on other high impact weather events including for instance thunderstorms, heavy rains and floods, extreme temperatures, etc.

2-D-2.5 17:00-17:15

The Roles of Blocking, Thermal Advection, Melting, and the Associated Thermodynamic Structure in Generating the Snowfall Distribution of the Great Western Storm

Douglas A Wesley, *Gregory P Byrd*
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During the period 17-20 March 2003, a major snowstorm and blizzard paralyzed the Front Range of the U.S. Rocky Mountains from east central Wyoming southward to northeastern Mexico. Snowfall maxima exceeded 2 m in portions of the foothills of the Colorado Front Range, and the overall economic impact in Colorado was estimated at $93 million. Extremely large snowfall variations occurred on spatial scales of 10 km or less, and interestingly in many locations the local snow depth maxima did not occur over relatively elevated regions. At the same time, some major local snow depth minima did not occur over relatively lower areas.

The complex dynamics and thermodynamics of this storm will be investigated to infer the primary causes of these variations, with the intent of improving future forecasts of extreme events. Overall, on spatial scales of 50-100 km, NWS forecasts of the storm were very good and the potential for extremely heavy snowfall was emphasized even several days ahead of the storm. This study will emphasize smaller-scale aspects of the storm.

The snowfall accumulations along the urban corridor were strongly influenced by the thermodynamic structure during the storm. Temperatures at or very close to freezing permeated elevations of 4500 to 6000 feet in some of the hardest hit regions, and snow depths were thus critically dependent on local thermodynamics; some degree of melting occurred during the early portions of the storm in nearly all areas at or below 6000 feet in elevation. Observed wind and temperature fields, along with those in meso-scale model simulations, have revealed a complex surface temperature field during the storm which was not intuitively obvious based on conventional explanations utilizing local terrain features and those located immediately upstream of the anomalies. The persistent surface wind field pattern was the result of a complex, highly three-dimensional blocked structure, and appeared to strongly influence the low-level temperatures. Other related factors such as low- and mid-level stability appeared to play important roles in the development of meso-gamma-scale warm regions that prevented heavy accumulation.

An understanding of how the local variations in surface temperature developed during such a relatively warm winter storm (for the Rocky Mountain urban corridor) is critical to improving snow depth predictions in this region. The following factors will be examined, on the local scale, regarding how the temperature anomalies, and the associated snowfall distribution, evolved: 1) blocking, the barrier jet, and its influence on local temperature advection patterns; 2) upslope/ downslope flow; 3) melting.

2-D-2.6 17:15-17:30

Arctic Winter Weather and Forecasting – Experience Helps

Paul Yang, *Ed Hudson, Lynda Schuler, David Aihoshi, Tim Gaines*
Environment Canada, Canadian Meteorological Aviation Centre–West, Edmonton, AB, Canada
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Forecasting for the Arctic, including Northwest Territories, Yukon Territories, and Nunavut, is always a challenge. Lack of data, insufficient representation of boundary-layer features in the NWP models, and the dominance of local effects (especially in the wind regimes) all contribute to the difficulties.

During the last several decades, forecasters have collaboratively collected a wealth of experiences in forecasting weather in the Canadian Arctic. To retain this valuable knowledge within the Meteorological Services of Canada (MSC), a handbook was developed representing the collective wisdom of Arctic forecasters. This handbook served two purposes. The first purpose was to provide training materials to forecasters new to the region. The second purpose was to provide ready access to information relevant to Arctic weather forecasting such as climatology, local effects, and forecasting tips.

In this presentation, challenges meteorologists face in forecasting for the Arctic, especially in winter, will be discussed. A number of climate features included in the handbook will be reviewed as well. Finally, the authors will present some of the tips collected from forecasters in the Canadian Meteorological Aviation Centre–West.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00

**complete abstracts cited under Poster Session, pp. 167-178*

P-15 (2-D-2)

Unusual Precipitation Sequence: March 23rd, 2003 Case Study. ***Teresa Canavan***[1], *Wendy Sanford*[2]

([1]Meteorological Service of Canada (MSC) – Atlantic Region, Dartmouth, NS, Canada; [2]Aviation and Defence Services (ADS), Greenwood, NS, Canada)

Session 2-D-3

Micro-Meteorology

Medeira Room/salle, Chair/chaise: ***Claude Labine***

2-D-3.1 16:00-16:15

Farm Emissions Estimates using an Inverse Dispersion Technique

Thomas K Flesch[1], *John D Wilson*[1], *Lowry A Harper*[2]
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[2]USDA–ARS, Watkinsville, GA, USA
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We demonstrate an inverse-dispersion technique to estimate gas emissions from farms. The technique combines a measurement of gas concentration downwind of the farm (within 1 to 2 km) with a dispersion model calculation to allow the inference of emissions. A backward Lagrangian stochastic dispersion model is used for this calculation. The model assumes an ideal Monin-Obukhov surface layer and takes as input the average wind velocity and direction, the surface roughness, and atmospheric stability. The advantages of the technique are simplicity in field observations and the ability to make remote observations. However, care must be taken to avoid situations where the assumption of an idealized wind field is invalid, and leads to errors in the inferred emissions. Using the technique we calculate ammonia emission from a swine farm and a cattle feedlot.

2-D-3.2 16:15-16:30

Winds around a Thick Hedge

John D Wilson[1], *Andrée Tuzet*[2]
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[2]Institut National de la Recherche Agronomique, Paris-Grignon, France
Contact: jaydee.uu@ualberta.ca

Cup and three-dimensional sonic anemometers were arrayed on either side of a long, dense hedge (height ~ 8 m, thickness ~ 3 m) standing on slightly variable terrain, and time series of wind velocity were registered for a range of incident wind directions, mostly during light, daytime summer winds. Fractional wind reduction was about equal (circa 80%) across all incident wind directions within about ±45 degrees from normal, and for winds from either of the two sides (between which surface roughness and slope differed).

Sonics placed hard against the upwind and downwind sides of the hedge showed that, whatever the incident wind direction, the wind at the leeward edge blows down the normal; and these entry and exit velocities permitted to estimate the product of bulk drag coefficient (Cd) and foliage area density (A). Simulations using the Reynolds-Averaged Navier-Stokes (RANS) equations with an eddy-viscosity closure, and based on the estimated value of (Cd A), gave a relative windspeed curve in reasonable qualitative agreement with the observations, even though the influence of thermal stratification was entirely neglected.

2-D-3.3 16:30-16:45

On the Relevance of a Diffusive Treatment for Heavy Particle Dispersion

Thomas Bouvet*, John D Wilson*
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The problem of dispersion of heavy particles in the atmosphere from an elevated source is important in agriculture, industry and public health, and an understanding of the mechanisms at play is crucial, if one is to be able to control the dispersion pattern. The mechanism of turbulent dispersion is popularly equated with “turbulent diffusion”, i.e., particles are assigned an “eddy diffusivity” that is considered to differ from (but be related to) the eddy diffusivity for the air itself. And it is a familiar result that, in the context of plumes of gas, the “eddy diffusion” description is valid only provided that the time (or distance) of travel from the source is large (the “far field limit”).

This presentation questions the validity of the eddy diffusion assumption for heavy particles, with arguments based on comparison between experimental, numerical and analytical results. The present work shows that diffusion is a good approximation for particles whose settling velocity is larger than 30 cm/s and which are released 1 m above ground. This cut-off settling velocity increases slightly as the source height increases too. For smaller particles, the travel time before fallout is not large relative to the average turbulence time scale along its path, and a diffusive treatment is not successful. In the case when the diffusion pattern applies, an analytical expression for the length scale (L) of the deposition swath can be derived (L is approximately proportional to the inverse of the particle settling velocity). This relationship is supported by experimental data.

2-D-3.4 16:45-17:00

Dispersion Modelling of Xe-133 in the Ottawa River Valley

Réal D’Amours[1]*, Alain Malo*[1]*, Kurt Ungar*[2]*, Ed Korpach*[2]*, Marc Bean*[2]*, Philip Davis*[3]
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A Lagrangian dispersion model is used at the Canadian Meteorological Centre for Environmental Emergency Response. This model is also used in the context of the Comprehensive Test Ban Treaty Organization (CTBTO)-World Meteorological Organisation (WMO) co-operation on source location estimation. The model will be described very briefly. A few case studies of dispersion of low level releases of Xe-133 from the nuclear research facilities in Chalk River will be presented and compared with state of the art radiological measurements at strategic points along the Ottawa River Valley. Hypotheses of release scenarios based on forward and inverse simulations will be discussed showing that atmospheric dispersion over rough terrain can be fairly complex and sometimes cannot be easily deduced from observational data alone.

2-D-4.1

16:00-16:15

Argo as an Aid to Environmental Monitoring and Assessment – the Example of the Gulf of Alaska

Howard J Freeland
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The spring of 2002 saw an unusual climate anomaly develop within the waters of the Gulf of Alaska. This anomaly was characterized by rapid warming at the surface and an injection of a large T/S anomaly between 80m to 150m depth. Much has already been written about this anomaly, its development and origin, and some descriptions of its impacts have been prepared. In the northern Gulf of Alaska the anomalies resulted in a massive stabilization of the water column through the spring, summer and fall of 2002. By February 2003 it was apparent that very little mixing had taken place in the upper ocean and that this would be restricting the supply of nutrients which potentially could be damaging to the productivity of the marine ecosystem during the spring and summer of 2003. These observations, largely based on results derived directly from the Argo array formed a large part of ecosystem assessments conducted in early 2003.

This paper will show how the unusual climate anomalies were observed by the Argo array, how these affected the stratification of the upper water column and how these observations were used to make contributions to the annual environmental assessments. Finally, the paper will present some preliminary results describing how the ecosystem actually behaved during the biologically active periods in 2003.

2-D-4.2

16:15-16:30

An Examination of Mixed Layer Depth along Line P and in the Gulf of Alaska

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[2]Institute of Ocean Sciences, Sidney, BC, Canada
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Mixed layer depths are computed, based upon a new method proposed by Kara et al. (2000), for historical measurements along line P, in the Gulf of Alaska. Fifty years of data are used for the monthly climatological calculations. To examine variability, the data is divided into two periods, based around the changes that occurred in the 1970s, except at station P, where a sufficient abundance of data permits the examination of the monthly mixed layer changes over 5 year pentads.

Mixed layer depths are also computed from Argo floats and mapped onto the line P stations using an objective analysis method. Argo data from 2001, 2002 and 2003 is used. Using the historical measurements for validation, the mixed layer depths estimated from the Argo floats agree quite well with the ship board observations. The 2003 data clearly shows the reduced mixed layer depths that occurred that winter. Finally, the objective analysis scheme is used to map the Argo mixed layer depths throughout the Gulf of Alaska.

2-D-4.3 16:30-16:45

Dimethyl Sulfide in Eastern Sub-Arctic Pacific: Flux Change during 1997-98 El Niño

CS Wong, *Shau-Kiing Emmy Wong, John S Page*
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Oceanic emission of dimethyl sulphide (DMS) to the atmosphere is a source of cloud-condensation nuclei, which can affect the global radiative balance. DMS flux in the eastern sub-arctic northeast Pacific at Ocean Station P (50 N, 145 W) showed large increase in summer and fall seasons during the 1997-1998 El Niño, although the winter values remained very low due to cooling.

DMS penetration from late 1996 to late 1999, reached 50 m depth with subsurface maximum with correlation to chlorophyll-*a*. The high DMS in northeast Pacific was compared to the global data basis. Possible causes due to changes in the ocean biology and wind are discussed.

2-D-4.4 16:45-17:00

Wind-Driven Inter-Annual Variability over the Northeast Pacific Ocean

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Inter-annual variability of the sea surface height (SSH) over the northeast Pacific ocean is hindcast with a reduced-gravity, quasi-geostrophic model that includes linear damping. The model is forced with monthly Ekman pumping fields derived from the NCEP reanalysis wind stresses. The numerical solution is compared with SSH observations from the Topex/Poseidon satellite altimeter at 1 degree resolution. Provided that the reduced gravity parameter is chosen appropriately, the results demonstrate that the model has significant hindcast skill over interior regions of the basin, away from continental boundaries. A damping time scale of 3 years is close to optimal, although the hindcast skill is only weakly dependent on this parameter.

A simplification of the quasi-geostrophic model is considered in which Rossby waves are eliminated, yielding a Markov model driven by local Ekman pumping. The results largely reproduce the hindcast skill of the more complete quasi-geostrophic model and indicate that the inter-annual SSH variability is dominated by the local response to wind forcing. There is a close correspondence between the leading empirical orthogonal function of the local model and that of the observed SSH anomalies. These modes appear to represent an analog to the Pacific Decadal Oscillation for the mass field of the upper ocean.

2-D-4.5 17:00-17:15

Revisiting the Juan de Fuca Eddy: Modelling and Observational Studies

Mike Foreman[1], *Emanuele Di Lorenzo*[2], *Barbara Hickey*[3], *Amy MacFadyen*[3], *Vera Trainer*[4]
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The Juan de Fuca (aka Tully) Eddy is a summer upwelling feature located off the entrance of Juan de Fuca Strait. Though Freeland and Denman (1982) demonstrated that it is comprised of California Undercurrent Water that has been upwelled onto the Vancouver Island shelf via the Juan de Fuca and Tully Canyons, they were vague on its precise generation mechanism. Our recent work suggests that the eddy is formed by an interaction of tides, estuarine flow, and winds. Preliminary model results will be shown and the role that the eddy seems to play as an initiation site for harmful algal blooms will be briefly described.

2-D-4.6 17:15-17:30

Parameterization of Subsurface Temperatures in the Lamont Ocean Model using Neural Networks

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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 inputs of the NNs are the six leading principal components (PCs) (i.e., EOF time series) of the thermocline depth anomalies, and the output is one of the five leading PCs of the subsurface temperature anomalies. Forced by the Florida State University wind stress, the ocean models were run from January 1964 to August 2001. The NN-enhanced Lamont ocean model simulated the sea surface temperature anomalies (SSTA) better than the original Lamont ocean model in the central and western equatorial Pacific. Improvements by the NN-enhanced model are also seen from the principal component analysis (PCA) and nonlinear principal component analysis (NLPCA) of the SSTA.

3-A.1

08:35-09:20
Plenary

Stewardship of our Earth Resources through a Comprehensive, Coordinated and Sustained Global Observation System

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In response to the World Summit on Sustainable Development in 2002 and the G8 Summit in Evian last year, the US hosted the first ever Earth Observation Summit, which charged an intergovernmental ad hoc Group on Earth Observations (GEO) with the development of a 10-Year strategy for a Global Earth Observation System of Systems (GEOSS). Social, economic and scientific needs are the primary drivers for building this comprehensive, coordinated and sustained system.

As the world's population continues to grow, we will face an evolving set of new challenges. A growing population will demand greater access to basic resources such as clean water and plentiful food. Trends indicate the concentration of populations, shifting from rural areas to urban centers, will dramatically alter the distribution of goods, services and land use. Many of these cities are located in coastal regions – the very regions we rely upon for healthy fisheries and reliable transport and navigation. With accelerating population comes increased potential vulnerability to natural disasters – we have already seen the considerable damage that is caused by floods and hurricanes, especially in those areas near coastlines. Given all these conditions, we must do a better job of managing resources.

A comprehensive, coordinated and sustained system will improve our understanding of major Earth systems processes and ultimately impart societal and economic value by providing us with better weather forecasting, agricultural planning, disaster preparedness mitigation, and prediction of infectious disease spread. Such a system will benefit countries worldwide and help shape sound decisions by policymakers, industry and citizens.

3-A.2

09:20-10:05
Plenary

Canada's Northern Oceans: Connectivity, Mechanics and Human Ties

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Human society, out of necessity, is now pressing to understand the vast network of interactions that connects it to the earth's ecosphere. In particular, emerging evidence warns that we humans, as a species and as a society, are inextricably linked to the patterns and fluctuations of ocean circulation and their impacts on climate. It is increasing clear that the three interconnected oceans that surround Canada - the North Pacific, Arctic, and North Atlantic - play a critical role in the transformation of the waters that feed the global thermohaline circulation, establish macroecological domains, and dominate global patterns of climate and biogeochemical flux. Each of Canada's three northern oceans is salt-, rather than temperature-stratified, and this distinguishes their dynamical and ecological behaviours from those of the more intensively studied oceans to the south.

A key to the Arctic Ocean's role in climate feedback is its dual behaviour as both a positive and a negative estuary: waters entering from the North Atlantic can become either lighter (positive estuarine circulation) or heavier (negative estuarine circulation) as they move within the Arctic interior. Here I focus on the positive mode. Freshwater components establishing and driving that positive estuarine circulation are delivered to the Arctic Ocean by atmospheric transport, and by riverine and oceanic inputs. Further distillation of freshwater may occur during the freeze/melt cycle.

Within the Arctic Ocean, freshwater is stored in various layers above and within the halocline. These serve as complex and poorly understood reservoirs that can dominate the magnitude of freshwater export southward on annual and decadal time scales. Indeed, the study of arctic climate is truly about the source, disposition, phase and export of freshwater. To illustrate, I will follow the path of freshwater on its 'downhill' journey from the North Pacific, through the Arctic, and thence into the North Atlantic, noting mechanisms and feedbacks that may impact humans. In the end it will be clear that Canada is surrounded not by three oceans, but by one - interconnected ocean – The Northern Ocean.

3-B-1.1 10:30-10:45

The Role of the Western Pacific in Decadal Variability

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Recent observational studies indicate that the mechanisms of Pacific decadal variability importantly involve the tropical Indian/western Pacific oceans and south Pacific convergence zone. Evidence for this suggestion is sought from the results of a 1000-year integration with the CCCma coupled ocean-atmosphere model which reasonably successfully simulates the principal mode of Pacific decadal-interdecadal variability. Both the western North Pacific, where ocean dynamics act to generate heat content anomalies, and the western South Pacific, where surface heat flux forcing acts to generate heat content anomalies, play a role. These heat content anomalies are advected to and eastward along the equator providing the negative feedback to allow the system to oscillate.

3-B-1.2 10:45-11:00

The Nonlinear Patterns of North American Winter Temperature and precipitation Associated with ENSO

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Nonlinear projections of the tropical Pacific sea surface temperature anomalies (SSTA) onto the North American winter (November-March) surface air temperature (SAT) and normalized precipitation anomalies have been performed using neural networks. During El Niño, the linear SAT response has positive anomalies centered over Alaska and western Canada opposing weaker negative anomalies centered over southeastern USA. In contrast, the nonlinear SAT response, which is excited during both strong El Niño and strong La Niña, has negative anomalies centered over Alaska and northwestern Canada, and positive anomalies over much of the USA and southern Canada.

For precipitation, the linear response during El Niño has a positive anomaly area stretching from the east coast to the southwest coast of the USA, and another positive area in northern Canada, in opposition to the negative anomaly area over much of southern Canada and northern USA, and another negative area over northern Alaska. In contrast, the nonlinear precipitation response, which is excited during both strong El Niño and strong La Niña, displays positive anomalies over much of the USA and southern Canada, with the main center on the west coast at around 45°N and a weak center along the east coast, and negative anomalies over the northern part of the continent centered around Alaska, and over Mexico.

For both SAT and precipitation, the nonlinear response accounts for about 1/4 as much variance as the linear response. A polynomial fit further verifies the nonlinear response of both the SAT and precipitation to be mainly a quadratic response to ENSO. The added variance from the nonlinear component of the response to ENSO found in this study can potentially contribute to additional seasonal forecast skill over North America.

3-B-1.3

11:00-11:15

Changing Influence of ENSO on Euro-Atlantic Winter Climate

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Previous studies have shown a lack of robustness of the Euro-Atlantic teleconnection response to ENSO. We study the response of a simple AGCM to ENSO variability in the periods 1958-1977 (P1) and 1978-1997 (P2) respectively. While the warm phase ENSO signal leaving the tropics in either of these periods has the characteristics of a wave train similar to the (negative) PNA, it is stronger and penetrates further northward in the later period. Meanwhile, the behaviour of the model to extratropical forcing shows a complete reversal in its response to ENSO variability from the P1 to P2 period, although in each period the response displays an AO type spatial pattern, just with opposite polarity. Whether the extratropical forced response is itself a product of the tropical forcing, or simply a product of chance cannot be conclusively determined.

3-B-1.4

11:15-11:30

The Influence of Tropical Forcing on the Arctic Oscillation

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A previous study has revealed that a primitive equation dry atmospheric model has some skill in predicting the amplitude of the Arctic Oscillation (AO) on the seasonal time scale. In a search for a possible source of the above skill, we regressed the observed seasonal-mean AO index onto the global precipitation field. The results show a temporal correlation between the AO index and a tropical Pacific precipitation pattern. The latter takes the form of a band of negative precipitation anomaly flanked by two bands of positive precipitation anomalies. We performed numerical experiments with the same model as above to test its response to heating/cooling anomalies corresponding to the observed precipitation anomaly patterns associated with the AO. Ensembles of four-month integrations were done with and without the thermal forcing anomaly. The ensemble mean, averaged over the last 30 days, were then analyzed. The results indicate that the atmospheric response to the thermal forcing, while not identical to the AO pattern, does project onto it. Part of the forcings (the part alone the equator) produces a PNA-like response while the reminder (off the equator) makes the main contribution to the AO-like atmospheric response.

3-B-1.5

11:30-11:45

Wavelet Analysis on Variability, Teleconnectivity and Predictability of East African Rainfall

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Applying wavelet analysis, wavelet based Principal Component Analysis (WLPCA) and wavelet based Independent Component Analysis (WLICA) to individual wavelet scale power and averaged wavelet scale power (SAWP), we objectively identified East Africa (EA) into zones of coherent variability and predictability. We also established links of teleconnectivity between the EA

September-November (SON) and March-May (MAM) rainfall and the Indian and the south Atlantic Ocean sea surface temperatures (SST). For SON, except at its western boundary, EA was found to exhibit a single leading mode of spatial and temporal variability. For MAM, southern Uganda and eastern Tanzania was found to be out-of-phase with the rest of EA. Wavelet analysis revealed that:

(1) EA suffered a consistent decrease of the SON rainfall from 1960 to 1997,
(2) EA suffered a consistent decrease of MAM rainfall from 1982-1997,
(3) the failure of the MAM rainfall triggered the most severe droughts in EA,
(4) the failure of SON rainfall resulted in droughts in Uganda and Kenya, and
(5) the SON rainfall is strongly linked to the SW Indian ocean and less strongly to the south Atlantic ocean, while the MAM rainfall is strongly linked to the NW Indian Ocean SST and the Brazil and Guinea ocean currents SST in the south Atlantic ocean.

Using predictors identified in the April-May-June season from the Indian and South Atlantic Ocean, the prediction skill achieved for the SON (2-months lead time) and MAM (8-months lead time) seasons by the non-linear, ANN-GA model was excellent but that by the linear, CCA model was modest.

3-B-1.6 11:45-12:00

On the Reliability of Climate Dynamical Predictions

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In this study, ensemble predictions were constructed using two realistic ENSO prediction models and using stochastic optimals. By applying a recently developed theoretical framework, we have explored several important issues relating to ENSO predictability including the reliability measures of ENSO dynamical predictions; and the dominant precursor that control reliability.

It was found that prediction utility (R), defined by relative entropy, is a useful measure for the reliability of ENSO dynamical predictions, such that the larger the value of R, the more reliable a prediction. The prediction utility R consists of two components, a dispersion component (DC) associated with the ensemble spread, and a signal component (SC) determined by the predictive mean signals. Our results show that the prediction utility R is dominated by SC. Using a linear stochastic dynamical system, we further examined SC and found it to be intrinsically related to the leading eigenmode amplitude of the initial conditions. This finding was validated by actual model prediction results, and is also consistent with other recent work. The relationship between R and SC has particular practical significance for ENSO predictability studies, since it provides an inexpensive and robust method for exploring forecast uncertainties without the need for costly ensemble runs.

Session 3-B-2
Hazardous Weather V – Emerging Forecast Methodologies
Piesporter Room/salle, Chair/chaise: ***Neil Taylor***

3-B-2.1 10:30-10:45

Current Status and Future Improvements in the Canadian Meteorological Centre's Operational Forecasting Suite

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The Operations Branch of the Canadian Meteorological Centre (CMC) runs, in a fully operational context, the models and analysis systems that have been developed by the Development Divisions of CMC along with MSC's research groups. The current status of the operational forecasting suite will be reviewed. The migration from the NEC/SX-6 to the IBM supercomputer was a major project in 2003. Now, in 2004, many improvements are planned to the operational system. These will be briefly described. They include the planned operational implementation of the 15km regional GEM model, the Ensemble Kalman Filter system, a new version of the CHRONOS air quality model with particulate matter (PM), an improved oceanic wave model, the SCRIBE Nowcasting system, GEM-LAM and GEM's meso-global, 4D-Var analysis, etc. We will also provide an update on CMC operational products including the Vizaweb interface (web browser to view NWP outputs) and the availability of CMC GRIB data to external users.

3-B-2.2 10:45-11:00

Scribe Nowcasting Sub-System – Version 1.0: First Objective Verification Results

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The SCRIBE Weather Forecast Product Expert System is now capable of ingesting the latest observations and nowcasting model data to update in real time the Scribe weather elements. This sub-system has been developed to minimize the necessary manual adjustments done by the forecaster to merge the current weather conditions with the forecast. Version 1.0 of the Scribe Nowcasting is currently using surface observations, North American radar mosaic data and lighting data from the Lighting Detection Network. These observations are used to feed short term forecast models. A statistical model called "PubTools" uses the surface observations to forecast the probabilities of occurrences of weather elements. The observed radar reflectivities are projected during the next 6 hours with a vector motion calculated from observed imageries 20 minutes apart. Finally, an algorithm has been developed at CMC to predict the probabilities of thunderstorm occurrences based on the forecast position of the lightning clusters.

All these observed and forecast data are processed by a rules base system to determine the best sequence of weather elements representing the current observation and short term tendencies. The first 6 to 9 hours of the Scribe weather elements will thus be influenced by the nowcasting data. Depending on the weather conditions and on how well the model handles these conditions, significant changes can be done to the regular Scribe weather elements. To assess whether these changes contribute to improve the first hours of the forecast or not, objective verifications was performed. For some weather elements preliminary results show that in the first 6 hours of the forecast the Probability of Detection has increased and the related False Alarm Ratio has decreased. Other verification scores also indicate an improvement of the short term forecast performance.

3-B-2.3 11:00-11:15

Nowcasting based on Surface Observations

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The first few hours of a public forecast are critical since they must closely match the observed conditions to be credible. Therefore, meteorologists put a special emphasis on that period. When the observed conditions at the bulletin issue time differ significantly from those expected, the forecaster workload is considerably increased. In an attempt to reduce the workload, a nowcasting module is in development at the Canadian Meteorological Centre.

This module ingests surface observations data (METAR) only to produce hourly statistical forecasts from zero- to 12-hours after initial time. The forecasts are generated every hour. Up to 40 years of hourly observations were used to develop forecast equations relating observations at initial time to observations at a later time. The equations are developed using a Multiple Discriminant Analysis (MDA) technique. The forecast weather elements are: sky condition, precipitation type, visibility, occurrence of precipitation and of convection. The probabilistic forecasts produced by the Multiple Discriminant Analysis component of the system may be converted into categorical ones using a scheme based on past performance. Verification results showing that the nowcasting module based on surface observations generally outperforms persistence after 2 to 4 hours depending on the weather element and issue time will be presented.

Les premières heures des prévisions publiques doivent correspondre de très près aux conditions observées pour être crédibles. Le météorologiste porte donc une attention toute spéciale à cette période. Lorsque les conditions observées au moment de l'émission des bulletins diffèrent significativement du scénario original, la charge de travail des prévisionnistes est fortement augmentée. Pour tenter de réduire cette charge, un module de prévision immédiate est en développement au Centre Météorologique Canadien.

Ce module ingère les observations de surface (METAR) pour produire des prévisions statistiques horaires de 0 à 12 heures. Ces prévisions sont refaites à toutes les heures. Jusqu'à 40 ans d'observations ont été utilisées pour développer les équations reliant les conditions au temps initial avec celles d'un temps ultérieur. Les équations sont produites par la technique MDA (Multiple Discriminant Analysis). Les différents éléments prévus sont la nébulosité, la présence et les types des précipitations, la visibilité et la convection. Les prévisions probabilistes produites par MDA peuvent être converties en prévisions catégoriques par l'utilisation d'un schème basé sur la performance. Des vérifications montrant que PUBTOOLS bat généralement la persistance après 2 à 4 heures, dépendant de l'élément et de l'heure d'émission, seront présentées.

3-B-2.4 11:15-11:30

Research and Private Sector Applications of the Aurora and FPA Graphical Database System

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Aurora and the Forecast Production Assistant (FPA) are software programs developed within the Meteorological Service of Canada for abstract representation and manipulation of meteorological information. Aurora was developed to provide a case study tool for research into various aspects of severe weather processes. Much of this development has its origin in the FPA, a graphical database which has been used in commercial applications since the mid 1990's. Both programs share the ability to represent various types of forecast and observational data at multiple scales in space and time. They can also be used to identify, synthesize, annotate, modify and interpolate or extrapolate features within the context of a graphical database.

The demands of research projects continue to stretch the limits of software for representing meteorological data. The importance of representation goes beyond mere visualization. Representation attempts to replicate the abstract constructs used by humans when thinking about conceptual models of the atmosphere. Accurate representation is fundamental to successful communication of ideas, a core tenet of science. Some forms of representation, such as grid point fields, are well established in meteorology. Other forms are not so well established, but are recognized in other disciplines such as geographic information science. Aurora provides a unique platform on which to test our ability to describe meteorological processes via computer algorithms. Researchers are able to attach software modules to a "representation engine" and exchange information with it in a database sense. Aurora enables subjective and objective interaction with spatial and temporal information which in meteorology is often uncertain or conflicting.

Some examples from case studies will be presented. Interestingly, the ability to represent meteorological information in conceptual form has found commercial application over the last 10 years via FPA. Graphical object representation brings new meaning to the notion of a "forecast digital database". Organizations are able to exchange conceptual information amongst distributed work centres, and use the database to ensure consistency amongst an extensive range of end user products. Meteorologists do not compete with models, but in the spirit of ongoing data fusion use all available information to keep their database current. At present, commercial users of the FPA run proprietary models initialized with FPA fields, and they also distribute a wide assortment of automatically generated graphical products. Various examples will be presented.

3-B-2.5 11:30-11:45

An Extreme Forecast Index for the Canadian Ensemble Prediction System – Slicing through all that Spaghetti

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Ensemble prediction systems (EPS's) have been functioning operationally at numerical weather prediction (NWP) forecast centres for more than a decade now. In contrast to the single forecast produced by deterministic NWP models, an EPS generates numerous forecasts, all valid for the same time. The set of solutions supplied by an EPS enables the estimation of the probability density of the forecast trajectory in the phase space of the NWP model. The EPS solutions also facilitate the generation of probabilistic weather forecasts, which can convey the degree of confidence intrinsic to a particular forecast. However, interpretation of the prodigious amount of output produced by an EPS can be a daunting task for the weather forecaster. Moreover, while outputs, such as spaghetti plots of mid-tropospheric control lines, clearly reveal the stochastic nature of numerical weather prediction, the relationship of this output to the prediction of those elements comprising a daily weather forecast is more tenuous.

The European Centre for Medium-Range Weather Forecasts is generating an extreme forecast index which supplies an objective measure of the degree by which the distribution of a set of EPS forecasts of meteorological variables, such as precipitation amount, temperature, and windspeed, deviates from the EPS model climate. Summary inspection of the index allows the forecaster to determine the potential, in the model climatology, for high-impact weather, and focus their assessment of the NWP guidance accordingly.

This paper discusses the exploration currently underway into the application of this index to the Canadian EPS. In place of empirical distributions for the EPS forecasts, parametric models were fit to the ensemble climate, in order to compensate for a comparatively small forecast sample. Use of distributions obtained by fitting theoretical distributions to the observational climate is also being investigated. Some preliminary results are presented in an attempt to characterize the temporal and spatial behaviour of the index, as well as its efficacy in providing advance notice of some recent high-impact events.

3-B-2.6 11:45-12:00

Ensemble Prediction – the Sixth Dimension

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Over the past century, weather forecasting has advanced from three dimensions (x, y, t) to four (x, y, z, t) to five (the many fields in four dimensions). Meteorologists have struggled to keep pace with the challenge of thinking and assimilating information in four or five dimensions. It has become very difficult and time-consuming to assess the evolution of a sophisticated numerical model. It can be argued that ensemble prediction systems represent a sixth dimension. An operational meteorologist cannot possibly study the integration of dozens or even hundreds of potential model solutions.

There is general agreement that determinism, as a foundation of weather forecasting, will vanish with time. Probabilistic forecasts, based on ensemble solutions, have greater potential value in contributing to risk-management decision-making. The aviation industry and others are already clamouring for this type of forecast information. Other economic and public safety sectors may base decisions on different meteorological parameters and probabilities. Complicating this evolution is the fact that the vast majority of Canadian public and industry will not be capable of interpreting probabilistic forecasts. Although, from a mathematics and physics point of view probabilistic information is simple to produce, it is not simple to present, especially to the uneducated decision-maker.

For decades, many so-called experts have been predicting the demise of the human weather forecaster. More and more have adopted this attitude; even some operational meteorologists have joined the lament. Change is continuous and operational meteorology will be no different. However, rather than with regret, the future can be viewed as filled with opportunity for meteorologists. Yes, the human weather forecaster, as we have known for 50 years, will gradually disappear. The applied scientist, with an understanding of meteorological processes at various scales, should have a bright future.

3-B-3.1 10:30-11:00 Invited

Observation and Modelling of Hydrothermal Vent-Induced Circulation at the Endeavour Segment of Juan de Fuca Ridge

Richard E Thomson[1], *Russell E McDuff*[2], *Marina M Subbotina*[3], *Mikhail V Anisimov*[3], *Steven F Mihaly*[1], *Alexander B Rabinovich*[1]
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Understanding how larvae from extant hydrothermal vent fields colonize neighbouring regions of the mid-ocean ridge system remains one of the major challenges in oceanic research. This, and related global problems, requires detailed insight into the mechanisms effecting currents in the deep ocean. Hydrothermal venting at Endeavour Ridge – Canada's first Marine Protected Area, situated 300 km west of Vancouver Island in the northeast Pacific – is focused at five major vent fields spaced at roughly 2-km intervals along a narrow (~1 km wide) north-south trending rift-valley. The heat flux from each of the larger vent fields is equivalent to the output from a modern heavy-water Candu nuclear power generating station. Extensive current meter observations reveal that tidal and wind-generated currents in the region are strongly attenuated within the rift-valley and that hydrothermal plumes rising from the vent fields could drive a steady (~10 cm/s) circulation within the valley.

A Princeton Ocean Model with an axially symmetric rift-valley within a stratified, full-depth (2400 m) ocean is used to simulate the circulation and associated temperature and salinity fields generated by vertical heat fluxes from the vent fields. Results confirm the major contribution of plume-induced flow to mean circulation within the valley. Extrapolation of these findings suggests that the suppression of oscillatory currents within rift-valleys of mid-ocean ridges shields larvae from cross-axis dispersal into the inhospitable deep ocean. This effect, augmented by plume-driven circulation within rift-valleys having active hydrothermal venting, helps retain larvae near their source. Larvae are then exported preferentially down-ridge during regional flow events that intermittently override the currents within the valley.

3-B-3.2 11:00-11:15

Insights into Sea Ice Thickness Distributions Derived from Ice Geometry

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The predicted feedback between climate and pack ice in the arctic pack ice is critically dependent on accurate modelling of ice thickness. Present models reproduce the general shape of observed ice thickness distributions in Arctic waters, but the amounts of thick ridged ice are generally overestimated. We derive insight into the processes that generate and ablate the thickest ice by adapting an ice thickness re-distribution model to local ice motion in the Beaufort Sea. The modelled evolution of sea ice thickness on a weekly time scale has been compared with observations by moored sonar. On local scales, the importance of the geometry of level ice floes to the distribution of ridged ice becomes evident. Ice ridge size and shape are limited by the finite size and strength of floes, so that observed ridges are smaller and contain less thick ice than their

modelled replicas. The porous internal structure of young ice keels may promote enhanced melting during the spring and summer seasons, thereby further reducing the amount of thick ice present. We generate improved simulations of ice-thickness redistribution by parameterizing geometrical information that describes the discrete keels and floes that make up the ice pack.

3-B-3.3 11:15-11:30

International Arctic Buoy Programme (IABP) – Applications of Buoys on Ice in the Arctic Basin

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Since 1979, agencies / countries have maintained an array of buoys on ice the Arctic Basin that provide meteorological and oceanographic data for real-time operational requirements and research purposes. Data from the buoys is used, for example, in forecasting weather and ice conditions; validation of satellites; research in Arctic climate and climate change; forcing, validation and assimilation into numerical models; and tracking the source and fate of samples taken from the ice. Many of the changes in Arctic climate were first observed and studied using data from the International Arctic Buoy Programme (IABP). For example, IABP data were fundamental to Walsh et al. (1996) showing that atmospheric pressure has decreased, Rigor et al. (2000) showing that air temperatures have increased, and to Proshutinsky and Johnson (1997); Steele and Boyd, (1998); Kwok, (2000); and Rigor et al. (2002) showing that the clockwise circulation of sea ice and the ocean has weakened.

This presentation provides a history of buoys on ice and present day efforts of the IABP to maintain an array of buoys on ice the Arctic Basin. Highlights of real-time operational applications of buoys-on-ice data and science applications and results using buoy data will be shared.

3-B-3.4 11:30-11:45

On the Formation and Circulation of the Intermediate Waters of the Gulf of St Lawrence

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The Gulf of St. Lawrence is a seasonally ice covered northern shelf sea that exhibits strong interannual variability in its water mass characteristics and circulation. In summer, the vertical water column in the Gulf is comprised of three layers: a warm and fresh surface layer, a deep saline layer of Atlantic slope waters, and a cold intermediate layer (CIL) which was formed during the previous winter. It is unclear, however, where and how the CIL is formed, how it circulates through the GSL, and to what extent inflowing waters from the Labrador Sea through the Strait of Belle Isle contribute to its formation. The results of a winter observation campaign that shed new information on these processes will be presented. The renewal of the CIL found in summer in the St. Lawrence Estuary is due to its advection into the region at the end of winter, rather than in situ formation. Deep mixing in the Estuary is prevented by strong winter surface stability, which

remains high throughout winter. The observations also suggest an intensified bottom layer circulation during winter, with the intrusion of warm Atlantic waters, usually found deeper than 150 m, at depths near 30 m.

A hindcast simulation of the winter 2002/3 was performed using a three-dimensional numerical ice-ocean model. The model reproduces the observed strong spring renewal event of the CIL into the Estuary, and helps to explain the role of local dynamics, including the stability of the Gaspé Current and the coupled circulation in the northwestern GSL, in controlling the exchange processes at depth. The model results suggest the existence of a stable offshore Gaspé Current, that is maintained by the combined effects of downwelling along the Gaspé coast and upwelling along the south coast of Anticosti Island. The results demonstrate that lateral and vertical structures of the estuarine circulation in the GSL undergo a strong and well-defined seasonal cycle.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00
**complete abstracts cited under Poster Session, pp. 167-178*

P-16 (3-B-3)
Canadian Long-Range Ice Forecasting in Hudson Bay. ***Adrienne Tivy***[1], *Bea Alt*[2], *Katherine Wilson*[3]
([1]Tivy Consulting, Ottawa, ON, Canada; [2]Balanced Environments Associates, Ottawa, ON, Canada; [3]Canadian Ice Service, Meteorological Service of Canada (MSC), Ottawa, ON, Canada)

3-B-4.1 10:30-10:45 Invited

Ground-Based Radiometric Profiling during Dynamic Weather Conditions

Randolph H Ware
Radiometrics Corporation and UCAR, Boulder, CO, USA
Contact: ware@ucar.edu

Water vapour, a fundamental driver of weather and climate, is highly variable in space and time. Ground-based GPS methods provide reliable, timely and accurate means of measuring spatial and temporal variability in atmospheric water vapour. These methods can be used to significantly improve short term weather forecasting and for climate research. For example, recent results show 7% improvement in forecast accuracy using precipitable water measurements from nearly 300 real time GPS sites in North America. In addition, it can be shown that continuous ground based GPS precipitable water measurements are sensitive to local and regional climate trends. These results and highlights of other progress in ground-based GPS sensing of atmospheric water vapour will be presented.

3-B-4.2 10:45-11:00

GPS Data, Products and Services for Meteorology

Pierre Héroux, *Paul Collins, Yves Mireault, Pierre Tétreault*
Natural Resources Canada, Geodetic Survey Division, Ottawa, ON, Canada
Contact: pheroux@nrcan.gc.ca

As part of Natural Resources Canada (NRCan), the Geodetic Survey Division's (GSD) primary role is to maintain, continuously improve, and facilitate efficient access to the Canadian Spatial Reference System (CSRS). The Canadian Active Control System (CACS), a nationwide network of continuously operating GPS tracking stations, is a component of CSRS that enables all Canadians to exploit the full potential of GPS. Through contribution of GPS data from the CACS network and participation as an Analysis Centre to the International GPS Service, NRCan influences the development and timely delivery of GPS products that are based on international standards and support the needs of the most demanding users, including the meteorological community.

This presentation will show the evolution of GPS orbit products that are essential for the estimation of water vapour. A simple approach to recovering integrated zenith tropospheric delays from a single station will be presented along with the features of an existing on-line application hosted at GSD. Finally, recent developments in internet access to global GPS tracking data and the implementation of algorithms that process undifferenced carrier phase measurements will show that real-time recovery of GPS water vapour estimates “in the field” may be possible in the not too distant future.

3-B-4.3 11:00-11:15

Evaluation of GPS Precipitable Water over Canada and the Global IGS Network

Godelieve Deblonde[1], ***Stephen Macpherson***[1], *Yves Mireault*[2], *Pierre Héroux*[2]
[1]Meteorological Service of Canada (MSC), MRB, Dorval, QC, Canada
[2]Natural Resources Canada, Ottawa, ON, Canada
Contact:stephen.macpherson@ec.gc.ca

The atmosphere-induced delay of global positioning system (GPS) signals reaching the earth, the zenith tropospheric delay (ZTD), is routinely estimated as a nuisance parameter in the processing of GPS data for geodetic (precise-positioning) applications. The ZTD depends mainly on the total atmospheric mass (surface pressure) and the integrated atmospheric water vapour (or precipitable water PW) along the path of the GPS signal. Thus, ZTD estimates can provide valuable information for monitoring PW in numerical weather prediction (NWP) and climate applications. Such measurements can be obtained at a much higher frequency than radiosondes, and retain their accuracy under all weather conditions, unlike radiance data from weather satellites or ground-based radiometers.

GPS observations can fill in both temporal and spatial data gaps for NWP applications. Before such data can be used operationally, however, an evaluation of the data is required through comparisons with other sources of PW data and with PW obtained from NWP analyses and forecasts. For data assimilation, a good estimate of the observation error is also needed. Results will be presented of an evaluation of GPS-derived PW (GPS_PW) through comparisons with that derived from conventional radiosonde data (RS_PW), analyses produced by the Canadian data assimilation system (ANAL_PW), and with 6-hour forecasts of the Global Environmental Multi-scale (GEM) NWP model (TRIAL_PW). The ZTD data are obtained from the Geodetic Survey Division of Natural Resources Canada for a network of Canadian GPS sites as well as from the International GPS Service (IGS) for global sites. We also estimate the average errors associated with GPS_PW, RS_PW and TRIAL_PW from the inter-comparison results. Results of an investigation into the impact of the assimilation of ZTD data on analysis accuracy, using a simple one-dimensional variational data assimilation system (1D-Var), will also be shown. A significant improvement in the accuracy of analyzed humidity in the lower troposphere can be obtained, especially in cases of moist (high PW) conditions. Such improvements ultimately impact the forecasts of humidity and precipitation that are based on the initial conditions provided by the analysis.

3-B-4.4 11:15-11:30

Estimates of Atmospheric Moisture in a Regional GPS Network

Victoria A Hoyle, *Natalya A Nicholson, Susan H Skone*
Geomatics Engineering, University of Calgary, AB, Canada
Contact vahoyle@ucalgary.ca

Southern Alberta experiences unique weather patterns owing to its proximity to the Rocky Mountains. Fast-developing storms that originate in the foothills can take forecasters and Albertans by surprise. Water is an important part of any weather or climate study because it has a high latent heat and thus by tracking water, heat movement is tracked as well. Traditional methods of collecting data on atmospheric water vapour (such as radiosonde) do not offer the spatial and temporal resolution necessary for high-resolution analysis of storm systems. In order to fully understand weather patterns, continuous water vapour data sets with high spatial resolution are

needed. GPS has been widely used for positioning and navigation purposes. Among other error sources, the troposphere causes a delay in the GPS signal received at the Earth through a hydrostatic component and a wet component. Once other sources of error are mitigated, the positioning problem can be inverted such that the total neutral atmospheric delay is solved for. From the total delay, the wet component can be isolated by applying a hydrostatic delay model. The hydrostatic delay can be determined with millimetre level accuracy using precise surface pressure measurements.

By using data from a regional network of GPS stations, spatial models of the water vapour can be derived in a local area. In the summer of 2003, a network of eleven GPS stations was deployed in southern Alberta for precise positioning and atmospheric water vapour determination. The spacing between stations was designed to be approximately 50 km in order to give optimal results for mesoscale numerical weather prediction. A data collection campaign ran in July 2003, and for this permanent as well as temporary stations were deployed. The data from these stations is being used to solve for the four-dimensional distribution of wet refractivity in the vicinity of the network using a tomographic technique. These results will be augmented with CHAMP refractivity profiles from GPS occultations that occur within or near the network, and microwave profiling radiometer zenith profiles of water vapour taken over the University of Calgary using a novel data assimilation technique. The resolution and accuracy of the augmented 4-D tomography solution will be assessed.

3-B-4.5 11:30-11:45

Comparing GPS and Radiosonde Derived Atmospheric Moisture during A-GAME 2003

Craig D Smith[1], *Susan Skone*[2], *GS Strong*[3]
[1]Climate Research Station, Environment Canada, Saskatoon, SK, Canada
[2]Geomatics Engineering, University of Calgary, AB, Canada
[3]Meteorological Consultant, Ardrossan, AB, Canada
Contact: craig.smith@ec.gc.ca

The Alberta GPS Atmospheric Moisture Evaluation (A-GAME) study was initiated in the summer of 2003 to assess the capability of a network of GPS receivers in southern Alberta to produce regional atmospheric moisture fields. The GPS network, when fully operational, has the potential to provide forecasters and researchers unprecedented 3-Dimensional regional moisture estimates at high temporal resolution with no costly expendables. This capability will be a valuable asset to examine atmospheric moisture dynamics in a region of complex terrain and could serve as a prototype for similar networks elsewhere in Canada. The prototype GPS network in southern Alberta consisted of fourteen GPS systems (many of which were accompanied by meteorological instrumentation) installed by the University of Calgary prior to the 2003 field campaign. Three radiosonde launch sites were located within the network to provide conventional observations for validation purposes. During a two week period beginning 12 July, over 70 radiosondes were launched from the airports at Airdrie, Olds-Didsbury and Sundre. Estimates of atmospheric moisture derived from the radiosonde observations are compared to concurrent measurements derived from GPS receivers in proximity to the radiosonde sites.

3-B-4.6 11:45-12:00

Wet Refractivity Modelling in a Regional GPS Network

Natalya A Nicholson, *Victoria A Hoyle, Susan H Skone, M Elizabeth Cannon*
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Global Positioning System (GPS) signals experience ranging errors due to propagation through the neutral atmosphere. These range delays consist of a hydrostatic component dependent on air pressure and temperature, and a wet delay dependent on water vapour pressure and temperature. Range delays arising from the hydrostatic component can be computed with accuracies of a few millimetres using existing models, provided that surface barometric or meteorological data are available. By using a regional network of GPS reference stations, it is possible to recover estimates of the slant wet delay (SWD) to all satellites in view. SWD observations can then be used to model the vertical and horizontal structure of water vapour over a local area, using a tomographic approach. Tomographic techniques used in wet refractivity modelling discretize the overlying atmosphere in some fashion. One method commonly employed uses three-dimensional volume boxes, voxels, and holds the wet refractivity value within each constant. Constraints may be applied to improve the solution for under-determined voxels. Another method uses a functional approach to describe the wet refractivity within discrete layers of the troposphere. The wet refractivity values of each layer are related via covariance information. Both methods have independently been used to recover wet refractivity fields with varying degrees of success, depending on network scale and geometry.

A regional GPS network has been installed in Southern Alberta by the University of Calgary. This network consists of fourteen GPS reference stations, ten of which are co-located with MET3A meteorological sensors. A water vapour microwave radiometer and a profiler are also located at the University of Calgary. Variable weather conditions occur in the foothills of the Rockies near Calgary, and the Southern Alberta network allows great opportunities to assess detection and modelling of severe weather events using GPS. A collaborative data collection campaign, Alberta GPS Atmospheric Moisture Evaluation (A-GAME), was run from July 14-28 2003 with the Meteorological Service of Canada.

In addition to GPS and meteorological data collected at network reference stations, atmospheric soundings were made from three locations within the network. In this paper, we conduct implementation and testing of an optimal 4-D wet refractivity model in the Southern Alberta network. The model results will be evaluated against truth data from radiosonde soundings.

3-B-5.1 10:30-10:45

Atmospheric Circulation Patterns of Extreme Lightning Events and Associated Wildfires in the Mackenzie Basin

Andrew M Way[1], *John R Gyakum*[1], *Bob Kochtubajda*[2]
[1]McGill University, Montréal, QC, Canada
[2]Meteorological Service of Canada (MSC), Edmonton, AB, Canada
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A study that examines the large-scale circulation features associated with extreme lightning events, defined as 2000 or more cloud-to-ground lightning strikes occurring over a 24-hour period, is currently being conducted for the Mackenzie Basin. The purpose of this research is to study synoptic-scale atmospheric circulation anomalies associated with the mesoscale phenomenon of lightning occurring in the Mackenzie Basin. The study compares these anomalies with those associated with lighter, more typical lightning events. Cases of extreme lightning are then stratified according to the occurrence of large wildfires observed following an event. Incorporated within this study are data from lightning detection network operating in the Northwest Territories, gridded data from the National Centers for Environmental Prediction (NCEP) digital archives, surface and upper-air station data, and data from the Large Fire Database operated by the Canadian Forest Service.

Preliminary results suggest the presence of an anomalously strong upper-tropospheric ridge located over the Mackenzie Basin several days prior to an extreme lightning event, which then rapidly breaks down at the onset of convection. In addition, a surface trough of low pressure is observed to intensify and move into the basin in the 48 hours in advance of an extreme lightning event. The Haines Index and horizontal moisture flux patterns have been analyzed to pinpoint the stability and moisture patterns associated with extreme lightning events in which the initiation of several large wildfires was subsequently observed. A strong positive Haines Index anomaly is noted directly over the basin in the 72 hours prior to this type of event, as well as a split moisture flux jet circumventing the basin. These patterns highlight a several-day period of rapid fuel drying and a thickening of the boundary layer just before a wildfire-producing extreme lightning event occurs.

3-B-5.2 10:45-11:00

Quantitative Precipitation Forecast Verification in the Edmonton Area

Olivier Bousquet, *Charles A Lin, Isztar Zawadski*
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Evaluation and verification of rainfall amounts forecasted by numerical weather prediction systems is generally accomplished through comparison of model forecasted precipitation against rain gauge measurements. Since gauge observations are only point values these verifications are subject to representativity errors. Because model outputs represent spatially filtered or averaged conditions, the causes of the differences when the two are compared can thus be due as much to differences in scale as to model errors. By continuously mapping the broad structure of rain events over large areas, ground-based meteorological radars can provide more coherent information about intensity and distribution of precipitation at multiple scales and may, as such, appear more appropriate for model verification purposes.

In this study, observations from the C-Band Carvel (Edmonton) operational weather radar will be used to verify rainfall amounts predicted by the experimental High Resolution Model Application Project (HIMAP) version of the Global Environmental Multiscale (GEM) for a period of 60 hours starting July 28th 2001 at 00 UTC. Many well behaved evaluation techniques such as the Root Mean Square Error (RMSE), the Probability of Detection (POD) and the False Alarm Rate (FAR), among others, will be used to evaluate the performance of the model during this 60-hour observation period. A key objective will be to investigate the impact of phase and time shifting on the quality of a given forecast. Another long standing question in model verification that will be addressed in this study is the scale dependence of the predictability of precipitation. Power spectra of observed and predicted accumulated precipitation fields for the 60-hour period of interest will be presented to determine more accurately which scales may (or may not) be predictable by the HIMAP model.

3-B-5.3 11:00-11:15

Modelling of Wind Climate in Yukon Mountainous Terrain

JD Jean-Paul Pinard
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For the past two decades the Yukon has seen much wind monitoring activity in the search for potential wind farm sites. Wind energy development is part of the Yukon's plan to mitigate the anthropogenic affects of climate change today. It is difficult and expensive to measure the wind climate at all possible locations in the territory. So it has become useful to look to computer numerical wind climate simulations as a tool to aid in identifying sites for further investigation. A new modelling technique called the WEST (Wind Energy Simulation Toolkit) has recently been used to simulate the wind climate of the mountainous southern Yukon. This presentation compares the WEST simulation of the Yukon to the measurements that have been made in the field. The results show promise for a toolkit that could eventually be used in the production of a Canada-wide wind atlas.

3-B-5.4 11:15-11:30

Permafrost-Climate Variations in the Mackenzie Mountains, NWT, Canada

G Peter Kershaw
Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB, Canada
Contact: peter.kershw@ualberta.ca

Climate change has implications for permafrost and in the discontinuous zone it has been suggested that predicted warming will result in degradation of permafrost-cored landforms. In the Mackenzie Mountains, Northwest Territories, there are permafrost landforms such as peat plateaux and palsas that exhibit characteristics indicative of permafrost degradation. Data from the 1940s to the present suggest a decrease in the areal extent of these landforms of approximately 1% yr^{-1}. In 1990 a number of microclimate stations were established along with thaw monitoring sites to evaluate the status of these permafrost landforms. Over the >10 yr record air temperatures have remained more-or-less stable or cooled by up to 1.5°C at the sites with the most continuous record. However, permafrost temperatures have warmed by approximately 1.0°C over the same time period.

At -150 cm depth mean annual temperatures in the permafrost-free wetlands adjacent to the palsas averaged >7°C warmer and remained >0°C throughout the year. The depth of thaw record for six sites suggests little change since 1990 but there has been substantial inter-annual fluctuations at some sites. The snowpack provides a temperature buffer between the atmosphere and the ground in winter. Palsas and peat plateaux occur as elevated mounds in peatlands that are otherwise flat and dominated by sedges. Wind passing over these level areas accelerates to pass over and around the upraised features and erosion of the snowpack leaves them with 25% the depth of snow which has significantly less insulative capacity than that covering the adjacent fen. Because of the thin to discontinuous snowpack on the palsas, they become snow free earlier in the thaw season and their surface layer of peat quickly dries out to insulate against summer heat gain. Air temperature alone is not a reliable predictor of permafrost distribution or status in the discontinuous permafrost zone.

3-B-5.5 11:30-11:45

Hydrologic Modelling of Athabasca River Basin by Meteorological, Land Surface and Hydrologic Models, and *a priori* Land Surface Data

Ernst Kerkhoven, ***Thian Yew Gan***
Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB, Canada
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A land surface scheme, ISBA (Interactions Soil-Biosphere-Atmosphere) of Météo France was applied to the Athabasca River Basin (ARB) to model its water and energy fluxes. Four major input datasets were used: the archived forecasts from the Global Environmental Multiscale Model (GEM) covering Western Canada from October 1995 to September 2001, the European Centre for Mid-range Weather Forecasts (ECMWF) global re-analysis (ERA-40) from January 1961 to August 2002, the 6 arc-second DEM of the Peace-Athabasca River Basin of the National Hydrology Research Centre, and the Ecoclimap global land surface dataset.

The sub-grid runoff algorithm of ISBA was modified by assuming the sub-grid distribution of soil moisture follows the Xinanjiang distribution, and the total baseflow follows the Euler's Beta function, to more accurately simulate the dominant interflow of the ARB. ISBA was run in a stand alone mode using a priori land surface parameters and forced by the higher resolution GEM model and the coarse ERA-40 data. ISBA's predicted runoff was then routed through the basin using a simple hydrological runoff model. Simulations using the GEM model data showed that the modifications made to ISBA significantly improved streamflow predictions despite requiring two fewer parameters.

Simulations using the ERA-40 data showed that it is possible to reproduce the annual variation in monthly, mean annual, and annual minimum flows as well as the mean annual peak flow using meteorological data at Global Circulation Model (GCM) scales without using downscaling techniques.

3-B-5.6 11:45-12:00

Producing the Drainage Layer Database for North America

Frank R Seglenieks[1], *Eric D Soulis*[1], *Murray MacKay*[2]
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[2]Meteorological Service of Canada (MSC), Downsview, ON, Canada
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The hydrological component of coupled atmospheric-hydrologic models requires the creation of the drainage layer database (i.e., stream channel network, slopes, etc.). This is often done from a digital elevation model (DEM) using a lowest neighbour approach, however this method can lead to incorrect flow directions especially with large grid sizes. Using a technique developed by the Waterloo Hydrology Lab at the University of Waterloo, the drainage layer database for North America was produced at varying resolutions. The projection used was based on the polar stereographic projection used by the Canadian Regional Climate Model (CRCM) for the Mackenzie Basin GEWEX Study (MAGS) at resolutions of 500, 200, and 51 km.

The procedure involved first obtaining the best possible DEM and land cover map. Currently the best available public domain data set for elevation is the GTOPO30 database and for land cover it is the Global Land Cover Characterization database. Both of these data sets have a resolution of approximately 1 km and are available for all of North America from the USGS.

The DEM was then verified so that it produced the correct derived river channels. To do this the river network derived from the DEM was compared to the river networks available in vector format from base maps of North America. The DEM was modified until the derived stream network produced drainage areas within 5% of measured values for all basins over 500 000 km^2.

Once the DEM was verified, the program WATMAP was used to derive the drainage layer database for various resolutions. This program divides the data sets into grid squares based on the required projection and resolution, then for each grid square it calculates the inflows and outflows around the perimeter of the grid square. From this, the program can determine the maximum outflow and inflow to derive parameters such as main drainage direction, secondary drainage direction, and channel slope. The program also has specific algorithms to deal with the difficult problems of diagonal flows and secondary flows from the same grid square. The inclusion of these algorithms ensures the final drainage layer database is the best possible representation of the actual flows. Finally, the drainage layer database of North America is presented for all the resolutions.

Session 3-B-6 – *Building Meteorological & Oceanographic Services in Canada I "How to get help from the Government"*

Chablis Room/salle, Chair/chaise: ***Harinder Ahluwalia***

3-B-6.1 10:30-11:00 Invited

Canadian Commercial Corporation

Bruce Fox
Canadian Commercial Corporation (CCC), Ottawa, ON, Canada
Contact: psc@cmos.ca

CCC (Canadian Commercial Corporation) is a Crown Corporation mandated to facilitate international trade, particularly in government markets. CCC builds confidence in Canadian exports by giving them the credibility of a government-backed performance guarantee that opens doors and leads to contracts with improved terms. As a result, since its inception, CCC has helped thousands of companies from across Canada close export deals worth more than $30 billion and facilitated sales to foreign governments and private sector buyers in more than 100 countries.

3-B-6.2 11:00-11:30 Invited

Industrial Research Assistance Program (NRC-IRAP)

Cal Koskowich
Industrial Technology Advisor, Industrial Research Assistance Program (NRC-IRAP),
Lethbridge Community College, AB, Canada
Contact: psc@cmos.ca

The National Research Council Industrial Research Assistance Program (NRC-IRAP) is a federal catalyst that links a diverse network of institutions, organizations, and programs to help Canadian small and medium-sized enterprises (SMEs) develop and exploit technology in a competitive, knowledge-based economy. Canada's nearly two million SMEs drive job and wealth creation in all sectors of the economy and annually, NRC-IRAP works with 12,000 of them to help increase their innovative and technological capacity. NRC-IRAP's over 250 Industrial Technology Advisors (ITAs) deliver customized NRC-IRAP services involving strong one-on-one relationships, which lead to a return on investment, job creation, and world-firsts by innovative Canadian SMEs.
Cal Koskowich, an NRC-IRAP ITA working with geomatics and remote sensing companies, will present some of the ways that NRC-IRAP works with university and SME-based clients in and related to the fields of meteorology and oceanography.

3-B-6.3 11:30-12:00 Invited

Canadian International Development Agency (CIDA)

Ruth Shapiro
Director, Canadian International Development Agency (CIDA), Edmonton, AB, Canada
Contact: psc@cmos.ca

CIDA is the federal government agency that supports sustainable development in developing countries in order to reduce poverty and to contribute to a more secure, equitable and prosperous world. Working with partners in the private and public sectors in Canada and in developing countries, and with international organizations and agencies, CIDA supports foreign aid projects in more than 100 of the poorest countries of the world. CIDA's objective is to work with developing countries and countries in transition to develop the tools to eventually meet their own needs.

3-C-1.1 13:30-14:15

NSERC Information

Dennis Blinn
Program Officer/Administrateur de programme, Research Grants/Subvention de recherche, Natural Sciences and Engineering Research Council (NSERC), Ottawa, ON, Canada
Contact: dennis.blinn@nserc.ca

Representatives from NSERC's Discovery Grants program will be presenting an update of what's new at NSERC. The presentation will cover topics such as new initiatives, the 2004-2005 budget and program updates. Results from the 2004 Discovery Grants competition will also be presented as well as a synopsis of how the Earth Sciences community has fared in past NSERC reallocation exercises.

Des représentants du CRSNG du programme des subventions à la découverte feront une présentation afin de familiariser les chercheurs des actualités au CRSNG. La présentation portera sur des sujets tels que les nouvelles initiatives, le budget 2004-2005 et des renseignements sur les programmes. Les résultats du concours de 2004 pour les subventions à la découverte seront également présentées ainsi qu'un aperçu des résultats des dernières exercices de réaffectation de fond au CRSNG en rapport avec la communauté des sciences de la terre.

A question period will follow the presentation.
Une période de questions suivra la présentation.

3-C-1.2 14:15-15:00

CFCAS Report to Canadians on Climate Science

Gordon A McBean
Institute for Catastrophic Loss Reduction, Departments of Geography and Political Science,
University of Western Ontario, London, ON, Canada
Contact: gmcbean@uwo.ca

The CFCAS, on the request of the Federal Government, is preparing a report to Canadians on climate science. The purpose of the report is to bring into the Canadian context what is known and not known about the science of climate change. This session will be primarily a discussion where the views of participants will be sought. What are the main conclusions of climate science to date? Where are the major uncertainties? How should be CFCAS gain the input of the broad community of Canadian climate scientists? What recommendations or types of recommendations do participants think should be made to governments?

The session will be convened by *Professor Gordon A McBean*, as Chair of the Board of Trustees of the Canadian Foundation for Climate and Atmospheric Sciences. All are welcome.

Session 3-C-6
Building Meteorological and Oceanographic Services in Canada II – "An Update"
Chablis Room/salle, Chairs/chaises: *Barry Green* and *Susan Woodbury*

3-C-6.1
13:30-14:00
Invited

MSC Technical and Service Direction Update

Philip Jacobson
Meteorological Service of Canada (MSC), Clients and Partnership Directorate, Gatineau, QC, Canada
Contact: Philip.Jacobson@ec.gc.ca

The MSC is always in the process of evolving and developing technology while adapting its service direction to address new requirements, needs and conditions. In this session, the MSC will provide a general overview of the status, plans and development work in some technical areas, in the context of its service strategy and direction. Some items which will be touched on include the regional forecast production database, a SCRIBE update, NWP update (+Ensemble +statistical forecasts), the renewal of the UV index, the climate data online web site, data feeds and radar data updates.

This overview will be given in the context of working with the meteorological private sector in meeting the needs of Canadians. It will provide the meteorological private sector an opportunity to be informed about MSC activities and plans so they can make the best use of these developments. It will also provide a forum for the MSC to gain an appreciation of the main issues from the viewpoint of the private sector.

3-C-6.2
14:00-14:30
Invited

Meteorologists and the Environment Sector

Grant S Trump
Canadian Council for Human Resources in the Environment Industry, Calgary, AB, Canada
Contact: psc@cmos.ca

Both industry and government have recognized the importance of human resource activities in the development of a skilled labour force. Human Resources Sector Developments (HRSD) has facilitated, through their Sector Council Program, the development of national sector councils mandated to document and deliver long-term strategies to assist in ensuring an adequate supply of appropriately qualified individuals to meet the employment and economic needs of a variety of sectors of the Canadian economy. The Canadian Council for Human Resources in the Environment Industry, CCHREI, a not-for-profit corporation, has been charged with these activities as they relate to environmental employment in Canada.

Collecting Labour Market Information (LMI), defining functional areas of employment, documenting national occupational standards, facilitating linkages between educators and practitioners and establishing national certification programs are several of the activities of typical sector councils. CCHREI has proposed to work with meteorological professionals across Canada to develop such a human resource strategy. The first step in any project is to gain greater insight into the current state of employment for a particular set of occupations with a view to development of a longer term strategies. A proposal that has been developed between CCHREI and the meteorological community to develop a national human resource strategy for meteorologists consistent with the strategy developed for environmental employment will be the major focus of the presentation.

3-C-6.3 14:30-15:00 Invited

Private Sector Initiatives

Susan K Woodbury
Chair, CMOS, Private Sector Committee, Dartmouth, NS, Canada
Contact: psc@cmos.ca

The CMOS Private Sector Committee has been working on behalf of the Private Sector Meteorological and Oceanographic (PSMO) companies to forge a new open and transparent relationship with the Meteorological Service of Canada (MSC). Our presentation will focus on new initiatives for the private sector which have been developed as a result of five CMOS/MSC regional workshops this past winter. We are exploring whether the private sector industry now needs a permanent secretariat or consortium to support the development of large-scale international projects. In addition, we will report on the progress of the CMOS Private Sector Directory.

3-D-1.1 15:30-15:45

An Unstable Semi-Implicit Scheme made Stable

Claude Girard, ***Michel Desgagné***
Recherche en Prévision Numérique (RPN), Dorval, QC, Canada
Contact: michel.desgagne@ec.gc.ca

A new stability analysis (Bénard, MWR October 2003) has demonstrated why the semi-implicit scheme used in the MC2 model for so many years could be unstable. We review the analysis, show how the scheme has been modified to resolve the instability and finally discuss the impact of the change. This modification in fact removes the need to use time off-centering or other more or less diffusive method to control the instability.

3-D-1.2 15:45-16:00

Large Atmospheric Computation on the Earth Simulator (LACES) with the Canadian MC2 Model – a Status Report

Michel Desgagné[1], *Wataru Ohfuchi*[2], *Gilbert Brunet*[1], *Peter Yau*[3], *Ron McTaggart-Cowan*[4], *Michel Valin*[1]
[1]Recherche en Prévision Numérique (RPN), Dorval, QC, Canada
[2]Earth Simulator Center, Yokohama, Japan
[3]McGill University, Montréal, QC, Canada
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A long term collaborative effort between scientists from the Earth Simulator Center (ESC), McGill University and RPN is now focusing on simulating the full life cycle of hurricane Earl (September 1998) with the Canadian MC2 Community Model. The goal is to produce a 1 km horizontal resolution forecast over a very large domain which covers the tropical phase and extratropical re-development of Earl. In fact, we wish to produce 8-9 days of simulation on a fine-resolution domain of size 11000 x 8640 x 67. This reference simulation will be used to validate various lower resolution simulations and to improve our understanding of the extratropical transition of hurricanes. Of course this represents a major computational effort that can only be performed - at least for the moment - on the Earth Simulator vector super-computer in Yokohama (Japan) using around 80% of the total resources of the system for up to 10 full days of computation.

This project also poses a real challenge for the MC2 modelling system itself considering that the computing work is distributed on 3960 vector processors (495 out of 640 nodes). Inter-processor communications are potentially becoming an issue with such a large number of processors. It also represents a real test for the numerics of the elliptic solver considering that an order 10 Giga-equations are solved at once by an iterative 3D pressure solver based on FGMRES. I/O is also a very important issue which must be treated carefully. Even the simple display of meteorological fields on horizontal planes is far beyond the limit of current display technology.

Project LACES is now into its production phase. Results from the beginning of the simulation can already be used for various studies. Technical aspects of the setup required to achieve such a large simulation will be described. Machine performance will also be presented as well as preliminary meteorological results.

3-D-1.3 16:00-16:15

MC2 Simulation of the Effect of Cloud Processes on Post-Cloud Aerosol

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We investigate the interactions between aerosols and clouds and rain in the Canadian Mesoscale Compressible Community (MC2) model by including advection of aerosol and aqueous-phase sources and sinks of aerosol, specifically explicit aerosol activation, in-cloud production of sulfate by oxidation, and cloud and rain evaporation. The cloud and rain size-distributions are represented by a double-moment microphysical scheme.

Simulations were conducted to investigate the dependence of cloud properties on the atmospheric aerosol for marine stratus cloud observed during the 1995 Radiation, Aerosol, and Cloud Experiment (RACE) at 15 km resolution. We demonstrated that after including explicit nucleation, the simulated cloud water content (0.5-1 g m^{-3}) and droplet number concentration (100-350 cm^{-3}) were closer to the observed values (0.5-0.8 g $^{m-3}$ and 200-500 cm^{-3}) compared to a simulation with an empirical treatment of nucleation. To study the effect of the cloud on the aerosol size distribution, we repeat the simulations including in-cloud sulfur oxidation. The post-cloud aerosol size distributions from the two simulations are compared.

3-D-1-4 16:15-16:30

Numerical Simulation of the 17-18 July 1996 Chicago Flood

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The Chicago flood of 17-18 July 1996 was a unique weather event because of the amount of precipitation (over 16 inches) and the river flooding that occurred across the metropolitan area. In addition, a portion of this event is the subject of a COMET (Cooperative Program for Operational Meteorology, Education and Training) flash flood and tornado forecasting case study. Examination of observational data reveals that the flood was produced by multiple mesoscale convective systems (MCS) that developed along a quasi-stationary warm front extending from central South Dakota to the southern tip of Lake Michigan. The initiation and subsequent evolution of the flood are not fully understood.

In this study two mesoscale numerical models (MC2 and MM5) are used to simulate this event. To improve the initial conditions, precipitation data is assimilated using a one dimensional variational (1dvar) approach. Preliminary results indicate that the numerical models capture several qualitative details of the flooding event, including the warm frontal boundary across the Midwest and the evolution of the low-level jet. The 1dvar has positive impact on the 48 h QPF in terms of the bias and threat scores. Results of other sensitivity experiments will also be presented.

3-D-1.5 16:30-16:45

An Assessment of MC2 Precipitation Simulation during the Intensified Observation Period of the HUBEX/GAME Project in China

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Up to 70% of China's annual natural disasters are due to floods causing by heavy precipitation. An accurate and timely flood warning system can help to minimize flood damage. A numerical weather prediction (NWP) model has the potential to be part of such a system, as it could provide precipitation to the flood forecast model with a significant lead time. Precipitation from NWP models is also important for the areas where surface observations from rain gauges are sparse or even not available. Precipitation is the single most uncertain atmospheric input to a flood forecast model. The first objective of the joint McGill-China project (Application of Coupled Hydrometeorological Modelling System for Precipitation and Flood Forecasts) is to assess the precipitation simulation from the Mesoscale Compressible Community Model (MC2) during the intensified observation period (May 1 to August 31, 1998) of the HUBEX/GAME (Huaihe Basin Experiment/GEWEX Asian Monsoon Experiment) project in China. Six heavy precipitation cases have been identified for study. The Huaihe River Basin is located between Yellow River and Yangtze River, with an area of 270,000 km^2. We set up MC2 at two horizontal resolutions (20 and 5 km). The MC2 20-km runs are initialized and driven laterally by CMC (Canadian Meteorological Centre) analysis without using any extra information from China. We compare MC2 precipitation with observations from 213 rain gauges over the Huaihe River Basin for the six cases. The preliminary results show a reasonable agreement, thus showing the potential of using model precipitation for flood forecast.

3-D-1.6 16:45-17:00

The New Regional GEM 15 km Model

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A new Canadian regional model has been developed at the Canadian Meteorological Centre (CMC). This development took advantage of the increased computational power to incorporate the most recent findings of meteorology. The increased horizontal and vertical resolution allows a more precise computation of the forecast and a better definition of the geophysical features. This increased resolution enables the introduction of a more sophisticated set of physical parameterizations. The assimilation of more satellite data such as TOVS-amsub and radiance-GOES will result in an improved humidity analysis. All of these will contribute to a better forecast of weather elements and more importantly precipitation and winds. Extensive testing in both summer and winter conditions was necessary to achieve the final configuration and included active participation of CMC operational meteorologists. The new model was proposed to run in parallel mode at CMC in February 2004, and will hopefully become operational this spring. The talk will first describe the changes involved in this delivery. It will then show upper air and precipitation verifications. Cases studies will finally be presented with examples that will stress the characteristics of this new model.

3-D-2.1 15:30-15:45

The Variability of the Labrador Current off Hamilton Bank

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Off southern Labrador, the offshore branch of the Labrador Current is a narrow frontal jet that appears strongly locked to the bathymetry associated with the shelf break and the upper continental slope. The current transports polar waters from the Arctic Ocean, and Baffin and Hudson bays southward onto the Newfoundland and Scotian shelves and the Gulf of St. Lawrence. Since spring 1979, BIO and NWAFC have maintained a near bottom current meter mooring near the 1000 metre isobath beneath the current core. The moorings are replaced on an annual basis; small differences in location from year to year make it difficult to detect interannual changes in current strength and direction. While the temperature at 1000 metres exhibits a seasonal cycle whose amplitude is 0.2ºC, there is no corresponding seasonality in the current speed or direction. Unfortunately, attempts to service this mooring using a research trawler rather than an oceanographic vessel resulted in a break in records from spring 1992 through to spring 1995; the exact period when winter convection was most intense in the Labrador Sea.

3-D-2.2 15:45-16:00

Current Structure and Variability in Flemish Pass in 2002-03

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Moored measurements, hydrographic and Acoustic Doppler Current Profiler (ADCP) surveys, and altimetry observations are used to describe the structure and variability of currents and hydrographic properties in the Flemish Pass region in 2002-03. Moored measurements from June 2002 to July 2003 at two sites across the Pass show a seasonal variation in the southward flow of the Labrador Current branch in the Pass (maximum depth of 1120 m), with greatest transport in winter.

Hydrographic (geostrophic) and vessel-mounted ADCP sections taken as part of the DFO Atlantic Zone Monitoring Program (AZMP) also indicate stronger flow in April 2003 than July 2003, but the geostrophic flow estimates indicate a shift of the baroclinic component of the current towards deeper water in July. Cross-slope and vertical current structure from the different datasets is intercompared. The current structure and transports are also compared with historical observations and numerical model estimates.

3-D-2.3 16:00-16:45

Water Mass Transport Rates in the North Atlantic with a Special Focus on the Labrador Sea

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The Labrador Sea is a particular basin in the North Atlantic as one of the few oceanic sites where surface waters are converted into mid-depth waters, forming Labrador Sea Water (LSW) through winter convection. Circulation patterns, freshwater content, and the properties of previously formed LSW all play a part in this process. In this study, the sub-polar North Atlantic circulation is studied, with a Labrador Sea focus, using two recently compiled climatologies based upon isopycnal and geopotential coordinates. The climatologies (1910-2000) are used in a diagnostic model to calculate transport rates. As variability of the Labrador Sea water masses is a fundamental part of the system its response to varying conditions will be investigated by employing three-year running means to drive the diagnostic model. Emphasis will be placed on examining the freshwater transports, including the linkages between the boundary currents and the gyre interior.

3-D-2.4 16:15-16:30

An Isopycnal View of Oxygen in the Northwest Atlantic

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In the Northwest Atlantic, the cold, fresh and oxygen-rich Labrador Current and the warm, salty and oxygen-poor Gulf Stream come very close to each other near the Tail of the Grand Banks of Newfoundland, where the long term mean distance separating them is merely 250 km. The distance separating these two currents becomes even smaller when meanders in the Gulf Stream move the stream northward. Given such small distances between water masses differing in temperature by several degrees Celsius, differing in salinity by 1.5 and differing in oxygen saturation by about 30%, the ocean mixing regime in the Tail of the Grand Banks Region can have a major influence on the T-S-O2properties of the Slope Water region. We present annual mean composite maps of temperature, salinity and oxygen on the 27.25 kg m^{-3} potential density surface, which corresponds to the “depth” of the dissolved oxygen minimum in the North Atlantic Central Water (NACW), south of the Gulf Stream. This density level also corresponds to the density of bottom waters in the Lower St. Lawrence Estuary, where a two-fold decline in oxygen levels has been observed since the 1930s.

A brief discussion of the link between the oxygen decline of the Lower St. Lawrence Estuary and changes in the ocean mixing regime from the Tail of the Grand Banks to the mouth of the Laurentian Channel will be presented. We will also describe recent progress made towards equipping Argo floats with the OPTODE oxygen sensor in order to begin routine monitoring of oxygen in the world ocean.

3-D-2.5 16:30-16:45

Surface Currents on the Grand Banks

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Data from four surface drifters deployed in October-November 2002 by Canadian Coast Guard were processed and analyzed to determine surface current velocities on the Grand Banks. Currents along the eastern shelf break are steady reflecting the offshore branch of the Labrador Current. Currents in the interior of the Grand Banks have small means and are highly variable. The currents and trajectories were simulated using the Princeton Ocean Model (POM) and WaveWatch 3 (WW3) wave model.

The domain for POM includes the Labrador Sea, N.E. Newfoundland Shelf and the Grand Banks. Along the open boundaries, constant transports and seasonal temperature-salinity climatology were specified. WW3, the third generation NCEP operational forecast wave model, was implemented on a fine-resolution 10 minute resolution grid for the Grand Banks and related Atlantic Canada waters, nested within an intermediate 0.5° resolution domain for the NW Atlantic, nested within a coarse resolution 1.0° resolution Atlantic domain.

Both models were forced by 6-hourly and one-degree surface winds from Environment Canada’s GEM. The surface waves induce a Stokes drift, which can be calculated from the two-dimensional wave energy spectrum. To the first approximation, the surface velocity can be considered the sum of POM generated currents and the Stokes drift. A second effect of the surface waves is to increase the flux of turbulent kinetic energy from waves to the ocean and thus modify the eddy viscosity profiles.

A comparison of the modelled and the measured surface currents shows that the inclusion of the Stokes drift significantly improves the simulation. Tidal currents, inertial currents and the partition of momentum input from wind stress between waves and currents will be discussed.

3-D-3.1 15:30-15:45

Drought Risk Assessment on the Canadian Prairies

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Agriculture and Agri-Food Canada (AAFC) monitors climatic conditions in agricultural landscapes of Canada, using rainfall statistics (percentiles, percentage of normal and total accumulations). As well, soil moisture and water supply conditions are monitored using a variety of sources. These variables provide an overview of prevailing conditions. Since 2002, an experiment was embarked upon to expand monitoring activities into an outlook assessment of what may happen a few months ahead.

The assessment result is a climatic risk map that indicates the termination, recovery or worsening of drought risk a few months ahead. Inputs for the Outlook Assessment include the current conditions, projections in the seasonal climate and probability of receiving certain thresholds of precipitation at a number of locations. When the confidence level is low in the input variables, the risk map is not produced but a narrative of risk is provided to interpret how agricultural resources and those who depend on them might be impacted. While the drought risk map is popular among producers and the agri-business in general, there are methodological challenges such as the lack of a numerical measure of risk and there are scale issues in input variables that need to be resolved

3-D-3.2 15:45-16:00

Winter Season Snow Water Equivalent Variability across Western Canada (1978-2002) Inferred from Spaceborne Passive Microwave Data

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Winter snow cover is an important source of freshwater for spring season reservoir filling and soil moisture recharge across western Canada. Time series of snow water equivalent (SWE) distribution are required to understand the spatial and temporal variability of snow cover, link this variability to atmospheric circulation, and identify sensitivity to drought and other circulation-induced anomalies. Spaceborne passive microwave radiometry offers one of the longest satellite time series, and its generally all-weather capability, wide swath width, and frequent global coverage, makes it very applicable to snow cover monitoring. Most importantly, the influence of snowpack volume scattering on emitted microwave energy allows the estimation of SWE from passive microwave brightness temperatures.

The Climate Research Branch of the Meteorological Service of Canada has a long standing research program in the development and application of spaceborne passive microwave SWE datasets. In this study, data from the Scanning Multichannel Microwave Radiometer (SMMR; 1978 - 1987) and Special Sensor Microwave/Imager (SSM/I; 1987-2002) are combined to examine SWE variability for a study domain that includes tundra, boreal forest, and open prairie regions of western Canada. Rotated principal components analysis shows that the leading spatial modes of winter season SWE variability have centres-of-action located in the Canadian prairies. Composite analysis of National Center for Environmental Prediction (NCEP) 500 mb geopotential height anomalies illustrate that ridge location and intensity over western North America plays the

dominant controlling influence on SWE distribution and magnitude. The passive microwave time series (1978-2002) was also merged with a conventional SWE dataset (1915-1992) to place recent SWE anomalies in a longer historical context. While the frequency of strong anomalies (both positive and negative) has been high during the past decade, anomalies during the recent satellite era are no more extreme than those observed in the historical data record.

3-D-3.3 16:00-16:15

Climate Impact on Net Ecosystem Productivity of a Semi-Arid Natural Grassland – Modelling and Measurement

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Models used to estimate net ecosystem productivity (NEP) during climate change should first be shown to simulate the effects on NEP of interannual variability in current climates. Energy and CO_2 fluxes simulated by the ecosystem model ecosys were compared with those measured by eddy covariance over a semi-arid ungrazed grassland near Lethbridge, Alberta to improve confidence in model projections of grassland NEP. Differences between simulated and measured fluxes of CO_2 and energy were within the range of uncertainty in measured fluxes during 3 years with declining precipitation (466, 363, 276 mm in 1998, 1999 and 2000 respectively). Standard differences between modelled vs. measured CO_2 and LE averaged over 3 years were 1.0 mol m^{-2} s^{-1} and 22 W m^{-2} which are comparable to standard errors estimated from eddy covariance measurements. However further research is needed to reconcile differences in modelled vs. measured ecosystem respiration.

Annual modelled NEP of the semi-arid ungrazed grassland was +59 g C m^{-2} in 1998, +5 g C m^{-2} in 1999, and -33 g C m^{-2} in 2000. Long-term modelled rate of C accumulation in this grassland under current climate was 26.3 g C m^{-2} y^{-1} which is consistent with C accumulation in semi-arid grasslands estimated from measurements and models elsewhere. C sequestration by the semi-arid ungrazed grassland rose by 1.6 g C m^{-2} y^{-1} under climate change projected by the Canadian Regional Climate Model II from the IS92a emissions scenario. Under modelled climate change, the increase in transpiration caused by rising temperature was fully offset by the decrease in transpiration caused by rising CO_2, thereby lengthening growing seasons and alleviating water deficits.

3-D-3.4 16:15-16:30

Daily Evapotranspiration Trends and Drought Monitoring using GPS Moisture

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Daily monitoring of diurnal trends in regional evapotranspiration over large areas has not been possible except through indirect means using semi-empirical formulae such as Priestley-Taylor. Monitoring of drought conditions is even more difficult, since no single definition of drought applies to all situations. For example, a meteorological drought may not constitute a hydrological

or agricultural drought, and visa versa. The University of Calgary Geomatics Engineering Department operates a network of GPS receivers on an average 50-km baseline north of Calgary. GPS signals provide estimates of precipitable water at high temporal resolution (60 minutes or less) in near real-time, providing potentially valuable information for convective storm forecasting and monitoring, NWP inputs, and other meteorological applications. In this presentation, we explore possibilities for monitoring daily regional evapotranspiration and seasonal drought conditions using GPS moisture data. Data from several GPS sites are utilized, along with radiosonde and soil moisture data, for a two-week period in July 2003 during the Alberta GPS Atmospheric Moisture Evaluation (A-GAME).

3-D-3.5 16:30-16:45

A Study of Climate Change, Water Availability, and Regional Socio-Economic Impacts in the South Saskatchewan River Basin

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This paper reviews the goals and methodology being employed in a new study of the South Saskatchewan River Basin (SSRB) which aims to examine linkages and inter-connections among climate change, water availability, and the regional socio-economic system. This involves understanding how potential climate change might affect both the availability of water and the demand and use of water in the basin. Interaction of these two, either from a hydrological point of view or from a social and economic point of view could have a significant on human society. An effort will be made to identify the nature and significance of these impacts to evaluate the vulnerability of the regional socio-economic system. Additional analysis will focus on the need and capacity of that system for adaptation to changes in climate-change-driven water availability.

This study consists of two main modelling components: (1) a physical component that will simulate the future availability of water in the SSRB under a range of possible climate change scenarios, and (2) a socio-economic component that will assess the impacts of changing water resource availability on major water users and the vulnerability of water users to changes in water supply. Methodologically, the study employs a disaggregated and distributed approach to simulating water availability and to estimating water resource demands and uses. The study emphasizes the use of existing models that will be calibrated and updated for the SSRB to address key issues. Some important contributions of the project will be to document current water use patterns and estimate the value of water use by type of use; to forecast the availability of water and water use for a time period in the foreseeable future; to assess the vulnerability of regional withdrawal and in- stream water users to changes in water supply and estimate the cost of such changes, to evaluate potential costs and benefits; and to examine policies and programs that govern water use and adaptation to potential change.

3-D-3.6 16:45-17:00

Global and Regional Atmospheric Water Balances

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The latest IPCC Technical Report indicates that precipitation on land areas in the northern hemisphere has increased by 10-15% over the past few decades while overall average land precipitation has increased by 2% over the last century. The origin of the extra water entering the atmosphere to allow this increased precipitation is still uncertain but has generally been assumed to be due to increased evaporation as a result of increases in air temperature due to global warming. In northern areas water flow to the ocean appears to be increasing in at least some rivers flowing to the Arctic and western Atlantic as a result of increased precipitation in cold regions. While, at the same time, other studies report water streamflow to the ocean from the land has decreased by 10% (or about 4500 Gt/yr) over the last century in areas such as the southwestern United States, China, Europe and the Indian sub-continent due to human water withdrawals mainly for irrigation and/or power generation.

This presentation will speculate, from a chemical engineering mass balance perspective, on how these observed changes support, or fail to support, two potential mechanisms for the observed climate changes. Is regional climate change mainly due to Greenhouse Gas (GHG) emissions or Human Enhanced Water Evaporation (HEWE)? What are the options for closing the Global and Regional Atmospheric Water Balances, which options make the most sense and how can the options be tested. The author feels greater efforts should be directed to studying water fluxes, natural and anthropogenic, to allow a more complete assessment of this question and what it can tell us about global changes.

3-D-4.1 15:30-15:45

The Relationship between Elevation and Monthly Precipitation Accumulations in the Alberta Foothills

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As part of the Foothills Orographic Precipitation Experiment (FOPEX), six meteorological stations were installed in a 45 km east-west transect between Caroline and Limestone Mountain in west-central Alberta. One of the objectives of FOPEX is to examine the relationship between precipitation and elevation in the foothills region east of the Rocky Mountain front-range. This region represents a gap in the observational network and is also a significant source region for early spring runoff into both prairie and northern river basins.

The FOPEX sites, located at elevations between 1070 and 2120 metres, have measured accumulated precipitation as well as other climate variables since August of 2001. Strong linear correlations exist between monthly precipitation and elevation when precipitation is greater than 60% of normal, with an average r2 of 0.79. This relationship breaks down when monthly precipitation is below 60% of normal, resulting in an average r2 of 0.54. For months with greater than 60% of normal precipitation, the slope of the precipitation-elevation relationships shows a linear increase with increasing monthly precipitation (resulting in an r2 of 0.85). Further, the precipitation-elevation relationship at a site can be determined using monthly precipitation observations at any of the other sites in the transect (with r2 values ranging between 0.76 and 0.94). Using these regression models, a technique has been developed to calculate precipitation anywhere in the transect using monthly precipitation from other locations along the transect.

3-D-4.2 15:45-16:00

Effects of Topographic Slopes on Hydrological Processes in the Penn State NCAR MM5-LSM Modelling System

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It has been widely accepted that land surface processes and their modelling play an important role, not only in large-scale atmospheric models, but also in regional and mesoscale atmospheric models. In the Penn State-NCAR fifth-generation Mesoscale Model (MM5) used has its origin at the Oregon State University land surface model (LSM). But in the MM5-LSM, hydrological processes that the horizontal distribution of surface water should be depended on the topographic slopes were not included. Topographic slopes will cause outflows from higher topography to lower. Then the horizontal distribution of surface water and the soil moisture should be changed. So, we wish to address this aspect of the problems.

We will compare with between the third kinds of different physical state's simulation (the MM5's simulations, the MM5-LSM's simulations and the MM5-LSM's simulations with topographic effect), we find that the LSM can improve the simulation of the surface energy balance with add soil moisture to the MM5. Then the horizontal distribution of surface water and the soil moisture will be more real in the MM5-LSM's simulations with topographic effects. Therefore the surface

energy fluxes will be different, including both the sensible and latent heat fluxes. Thus it is expected the modifications will not only affected the weather simulations but also the climate simulations.

3-D-4.3 16:00-16:15

Orographic Effects and Sandstorms Observed in East Asia

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Observations of anti-cyclogenesis on the upwind side and cyclogenesis on the lee side of the Korean Peninsula are carried out. It is observed that the formation of synoptic- and meso-scale weather systems occurs around the Korea Mountain ranges, which average 1,000-2,000 m elevation. The cross-barrier flow at the 850-500 hPa levels produces a circular pressure system at the surface.

The Haanra Mountain in Jheju Island in southern Korea often generates synoptic-scale vortices as far as 800 km downstream. This isolated mountain produces cloud-free sections and regenerates vortices, including rainy clouds for long distances downstream, with a northwesterly airflow in the cold season. Over 30 typical cases of von Karman vortices have been gathered from satellite images. The atmospheric impact of a typhoon over Korea, producing upslope rainfall amounts of 870 mm in one day, is also discussed.

In general, a severe sandstorm and associated heavy dustfall events occur during spring. The source regions of Mongolia and northern China produce 60-120 dusty days. The continuous monitoring of sandstorms and dustfall is carried out with remote sensing of visibility and dust from satellites. The formation of a giant sandstorm and subsequent downwind transport to North America is discussed. It is reported that desertification occurs over northern China and Mongolia. However, the frequency of sandstorm formation has decreased during the past decade with the increase in rainy days.

3-D-4.4 16:15-16:30

Upstream Orographic Blocking on the Mediterranean Side of the Alps – a MAP Case Study

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Because upstream blocking can displace orographic forcing away from the windward slopes of steep terrain, understanding its behaviour and underlying mechanisms is required in order to better forecast the type, amount and location of orographic precipitation generated in the vicinity of major mountain ranges. A particularly strong case of upstream blocking occurred during the IOP-8 (21 October) of the Mesoscale Alpine Programme (MAP) that was conducted over the European Alps in autumn 1999. On this day, a pronounced blocked flow that developed in response to the deflection of baroclinically-induced southeasterly flow impinging on the barrier at low levels was observed to extend from the base of the Alps toward the Mediterranean Sea.

A particularly notable jet of northerly flow jetting out over the sea evidently helped trigger convection over the Gulf of Genoa, such that convective instability associated with moist unstable air originating over water was released far upstream of the Alps. This resulted in a significant reduction of precipitation over the Alpine slopes relative to what might have occurred in the absence of significant blocking. During IOP 8, an unexpectedly strong downslope flow was also observed within all major rifts along the south-facing slopes of the Alpine barrier. The presence of multiple, simultaneous down-valley flows was a further indication of the strong degree of blocking on this day, and acted as an additional source of cool, stable air serving to reinforce the low-level blocked flow banked up along the barrier.

In order to investigate the actual characteristics of the blocked low-level flow, dual-Doppler radar observations are extensively relied upon to perform a 'barrier-scale' mass budget and determine more precisely the degree of blocking and the location of sources and sinks of mass within the Po basin. Additionally, airborne Doppler radar data collected by the NOAA P-3 are also exploited to derive quantitative budgets within deep Alpine valleys and to estimate the potential impact of this additional mass of cool air on the mesoscale (barrier-scale) circulation.

3-D-4.5 16:30-16:45

Weather and Mountain Waves Forecast over Central and Southern Andes

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The aim of this work is to show some applications of weather forecasts for aviation meteorology over the neighbourhood of the Andes chain in Argentina, where westerly wind circulation is prevalent. As the winds cross these mountains, gravity waves are frequently generated, producing some topographically-forced phenomena such as trapped lee waves, rotors, rotor cloud structures and so on. Using a motor sailplane, attempts of world and regional records were made by a team of airmen, from November 2003 to January 2004. The accuracy of weather forecasts of gravity-wave generation and propagation over complex terrain was crucial for this activity. Two-times a day numerical weather forecasts were produced for the whole period. A modelling system with different mesh grid resolution was used for the study of mountain waves over this area. Particularly, the analysis of lee waves has been made to underline the basic and the fine characteristics of the orographic flows, also shown by many photographs taken during the flights. In particular, a few days were deeply analysed, comparing the simulated data with the observations, including data from the aircraft.

The simulations have been performed with a nonhydrostatic mesoscale model, nested in a global circulation model (GCM). Unfortunately, mountain-induced rotors remained hardly defined and difficult to forecast due to the particular terrain characteristics, which influence both the speed and direction of terrain-forced flows. Nevertheless, most of mountain wave clouds observed over Andes were consistent with the overall characteristics of airflow expected over these mountains, particularly lee waves, producing spectacular lenticular clouds, also shown by aerial photographs. Finally, weather situations during the observed period have been compared with the climate of this area, showing anomalies in the pressure distributions as well as the wind regime.

4-A.1 08:35-09:20 Plenary

Hurricanes in Canada: the Threat, the Impacts, Forecast and Research Challenges

Jim Abraham[1], *Peter Bowyer*[1],*Chris Fogarty*[1], *Walter Strapp*[1], *Mengistu Wolde*[2]
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Extratropical transition (ET) has been raised as a forecast research challenge by meteorologists from all ocean basins affected by tropical cyclones, including Australia, Canada, China, New Zealand, United States, and United Kingdom. Over each of these basins, the poleward movement of a tropical cyclone (TC) into the midlatitudes is normally associated with the weakening or decay stage of its lifecycle. A common problem in all these regions that experience ET is the difficulties accurately predicting the behaviour (track, intensity, and impacts) of these rapidly-changing systems. The most challenging issues are associated with the potential large amounts of precipitation, continued high wind speeds, and generation of large ocean surface wave heights and swell during the ET event. These severe impacts can and do occur after the tropical cyclone has weakened, and is no longer being classified as a TC so that advisories have been discontinued by the TC Forecast Centre. Furthermore, the forward speed of these storms typically accelerates from a typical 5 m/s in the tropics to in excess of 25 m/s in the mid-latitudes.

In Canada the impacts from an ET over land are related to the intensity of surface winds and precipitation, as well as the changes in their distribution - with strongest winds to the right of track, and heaviest precipitation to the left. In 1954 Hurricane Hazel transformed into an intense extratropical cyclone. Hazel resulted in 83 deaths in the Toronto area of Southern Ontario, Canada from extensive flooding from the extreme precipitation totals of 200-300 mm. Extremely high waves, surf and damaging storm surges threaten the marine and coastal environments.

The First International Workshop on the Extratropical Transition of Tropical Cyclones took place from 10-14 May 1999 in Kaufbeuren, Germany (Jones et al., 2004). Forecasters and researchers discussed the ET scientific challenges, and made a number of recommendations. One major recommendation included conducting of an ET Field Program: Our knowledge and understanding of extratropical transition could be enhanced through a field experiment with Intensive Observation Periods. In response to this challenge, the Canadian Search and Rescue Secretariat have funded a two-year research project into Atlantic hurricanes affecting Canadian interests. The primary goals of the project are to collect data from tropical cyclones undergoing extratropical transition in order to better quantify the threats, as well as to improve the understanding of the structure and predictability of these systems. In addition, the Canadian National Research Council (NRC) is mandated to conduct flight research to better assess hazards to the aviation industry. The MSC and NRC are partners in equipping their Convair-580 aircraft with meteorological instrumentation such as a GPS dropsonde system, cloud microphysical probes, and meteorological radar. In 2003, two hurricane research flights were conducted: the first into the remnants of Hurricane Isabel over southern Ontario; and the second into Hurricane Juan just prior to landfall in Nova Scotia.

Data from the Hurricane flights will be presented in this talk to illustrate the structural changes and potential impacts from hurricanes undergoing extratropical transition. Included will be aviation-related hazards documented from flights into four ET storms. Given Hurricane Juan was the most damaging hurricane in over a century for Halifax, N.S., with hundreds of thousands of

Maritimers in Nova Scotia and Prince Edward Island losing power (some for near 2 weeks), and dozens of buildings losing roofs, and 100 million trees blown down this presentation will also include a pictorial presentation to highlight the storm and its impacts on the two affected provinces.

4-A.2 09:20-10:05 Plenary

Micrometeorology and Carbon Balance Research in Northern Forests

T Andrew Black
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The boreal forest is the world's second largest forested biome occupying the circumpolar region between 50° and 70° north. This heterogeneous biome stores about 25% of all terrestrial carbon. In recent years, high rates of warming have been observed in this biome, which could significantly affect its carbon balance. Since the early 1990s, there have been a number of research initiatives aimed at quantifying the exchange of carbon between the boreal forest and the atmosphere, and understanding the controlling processes. Meteorology is a major component of this research. This paper will focus on the important role of the micrometeorological flux measurement technique, known as eddy covariance (EC), in measuring CO_2, sensible heat and water vapour fluxes near the surfaces of boreal forests and bogs. The surface CO_2 flux or net ecosystem exchange (NEE) is the difference between CO_2 loss to the atmosphere due to microbial decomposition of plant residues (heterotrophic respiration) and photosynthetic sequestration of carbon in plant biomass. Nighttime NEE measurements are valuable because they provide a direct measurement of ecosystem respiration.

This paper will interpret the results of EC CO_2 flux measurements, which have now been made at 24 boreal sites. Some sites, such as aspen stands, are moderate carbon sinks, while others, such as black spruce stands, are weak sinks or sources. Long-term EC measurements, ongoing at 9 boreal sites, have shown the strong impact of spring weather and drought on annual NEE. As a result of tower flux networks such as Fluxnet Canada, progress is being made in estimating net exchange at the regional scale, accounting for the effects of disturbance such as forest fires and logging. Aircraft EC flux measurements, convective boundary layer CO_2 budgets and measurements stable isotope composition of CO_2 in the surface layer are important meteorological techniques for validating scaled-up tower-based estimates of regional CO_2 exchange.

4-B-1.1 10:30-10:45

Past and Future Fire Weather: What is the Climate Change Outlook?

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Fires burn an average of 2 to 3 million ha of Canadian forest annually. Although fuel and ignition are critical for fire occurrence, weather largely determines fire growth and final fire size. Projections of future fire weather using global and regional climate models suggest that warmer and drier conditions will increase fire weather indices throughout much of western Canada in a 2xCO_2 scenario. When CO_2 concentrations increase to 3x current levels, most of Canada will experience weather that is more conducive to fire, possibly doubling the total area burned for all Canada. However, there will be some areas where little change is expected, and areas where there may be even a decrease in fire weather severity. Some parts of Canada may also see an increase in fire season length or an increase in lightning causing more ignitions. Analyses of weather associated with fires greater than 200 ha in size that occurred over the last 40 years do not show clear trends in fire weather indices. This is because of large interannual variability among individual fires, even within a given ecozone. Also, large fires typically grow during severe fire weather, which has occurred at a sufficient historic frequency to make the boreal forest a fire-dominated ecosystem. This large variability will make it difficult to detect climate change signals, although longer improved data sets will strengthen the analyses.

4-B-1.2 10:45-11:00

Estimating extremes in Transient Climate Change Simulations

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Changes in extreme temperatures and precipitation described in terms of return values of annual extremes are examined in three ensembles of transient climate change simulations performed with the second generation global coupled climate model (CGCM2) of the Canadian Centre for Climate Modelling and Analysis. Three-member ensembles were produced for the time period 1990-2100 using the Intergovernmental Panel on Climate Change IS92a, A2 and B2 emission scenarios. The return values are estimated from a generalized extreme value distribution with time-dependent location and scale parameters fitted to 51-yr samples of annual extremes by the method of maximum likelihood. The method of L-moments for estimating return values is revisited and found to produce biased estimates of return values in the considered transient climate change simulations.

The climate response is of similar magnitude in the integrations with the IS92a and A2 emission scenarios but more modest for the B2 scenario. Changes in temperature extremes are largely associated with changes in the location of the distribution of annual extremes without substantial changes in its shape. Exceptions from this general rule occur in regions where land and ocean surface properties change drastically, such as the regions that experience sea-ice and snow cover retreat. Globally averaged changes in warm extremes are comparable to the corresponding changes in annual mean daily maximum temperature while globally averaged cold extremes warm up faster than annual mean daily minimum temperature. There are substantial regional differences

in the magnitudes of changes in temperature extremes and the corresponding annual means. Changes in precipitation extremes are due to changes in both the location and scale of the extreme value distribution and exceed substantially the corresponding changes in the annual mean precipitation. Generally speaking, the warmer model climate becomes wetter and hydrologically more variable. Waiting times for precipitation events that are considered extreme at the beginning of the considered simulations are reduced by a factor 1.5-2 by the end of the 21st century.

4-B-1.3 11:00-11:15

Monitoring Air Quality and Climate Change Occurring over East Asia

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In the present study, we discuss the large-scale transport of smoke plumes from forest fires occurring in Korea and in Far Eastern Russia. The number of forest fires occurring over Russia is known to be twice that occurring in Canada. East Asia has become the third industrial region of the world, and continuous monitoring of pollutant transport has been made since 1993. Ground-based measurements are being combined with remote sensing data by NOAA-N and Geo-stationary satellites. Acidic precipitation (mean pH ~4.9) frequently occurs over Korea due to air pollutants coming from the Yellow Sea. However, observed values of pH have increased in recent years.

The level of surface ozone in eastern North America shows a maximum during the warm season. In contrast, observed ozone values in Korea have shown peaks in both May and September. In North America, NOx emissions are a main source of surface ozone, and both NOx and CH4 are the chief precursors for ozone generation in Korea.

At the western tip of central Korea, the annual mean CO_2 concentration was 360 ppm in 1991, reaching 379 ppm in 2003, or as high as at Alert in the Canadian Arctic. Atmospheric CO_2 values have been steadily increasing at the rate of 1.5 ppm per year. Measured values of CH4, N_2O and CO are also increasing significantly

Annual mean air temperatures over Korea have increased by 0.6 to 2.5ºC in the past 25 years, with similar temperature increases in Mongolia, central and northern China, and in Japan. The annual amount of precipitation in Seoul has increased about 182 mm, with a shorter period of summer rainy days in Korea, and replaced by heavier convective precipitation amounts. The northward shift of a “quasi-stationary polar” front in recent years also results in heavier amounts of rain over Mongolia and higher latitudes. With the steady increase in GHGs and air temperatures in East Asia, we propose that these regional changes are related to general climate warming, with resulting increases in snow and ice melting over the Arctic Ocean.

4-B-1.4 11:15-11:30

Changes in Relative Humidity in Canada during 1953-2003

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Hourly measurements of relative humidity, collected at 75 stations located throughout Canada during 1953-2003, were examined. Statistically significant decreases in relative humidity were evident throughout all regions in winter and spring. Fewer and weaker trends occurred in summer and fall. The data was carefully examined to account for possible effects due to changes in procedure and instrumentation such as the replacement of the psychrometer by the dewcel in the 1970s. The latter change affects data taken at very cold temperatures during the winter. However, the decreasing relative humidity trends remain at southern and coastal stations. Finally, the trends were found to be closely correlated with statistically significant changes in dew point, temperature and precipitation.

4-B-1.5 11:30-11:45

Climate Sensitivity and Climate Change under Strong Forcing

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Experiments to investigate the nature and behaviour of the simulated climate under modest to very strong forcing are undertaken with versions of the NCAR and CCCma models. We are interested in the climate feedback/sensitivity of the models, the robustness of model parameterizations as forcing levels increase, and the possibility of a "runaway" warming under strong forcing. The models are forced by increasing the solar constant by 2.5, 10, 15, 25, 35, and 45% of its control value. Feedback processes are analyzed both locally and globally in terms of longwave and shortwave, clear-sky/surface and cloud forcing components. A "runaway greenhouse effect" for the earth can result when the greenhouse effect of increasing water vapour in a warmer atmosphere overwhelming the negative feedback of the longwave cooling to space. The NCAR model does experience a runaway warming for strong forcing but it is, instead, a "runaway cloud feedback" warming. Preliminary results for CCCma CGCM2 show a considerably different response to strong forcing and the model does not experience a corresponding runaway warming (results for CGCM3 are not yet available). The behaviour of feedback mechanisms at both weak and strong forcings are important to understanding the climate system. The possibility of strong warming arising from positive feedback mechanisms that are felt only when the system warms sufficiently are potentially important and can only be investigated with fully coupled models of the climate system.

4-B-1.6 11:45-12:00

Winter Temperature Trends in Central BC Airmass Frequency and Synoptic Climatology

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Winter temperatures are found to have a disproportionate influence on the annual mean in central British Columbia. January temperature trends revealed by the cumulative deviations of temperature show decadal variations that correlate with the PDO. A synoptic climatology of the above normal and below normal temperature periods shows a significant relationship with the depth of the Aleutian Low and the longitude of a 500 hPa ridge in the eastern Pacific.

Periods of above normal January temperatures have a more intense Aleutian Low, positive 500 hPa height anomalies over southern BC and negative 500 hPa height anomalies over the Aleutian Islands – all of which contribute to southerly/warm advection. Periods of below normal temperatures show the opposite: positive sea level pressure anomalies in the Aleutian Low area, positive 500 hPa height anomalies over the Aleutian islands and negative 500 hPa height anomalies over southern BC – all of which contribute to enhanced northerly/cold advection.

The frequency distribution of January temperature is bimodal: the colder mode corresponds to the presence of continental arctic air, and the warmer mode corresponds to the presence of maritime polar air. The relative frequency and temperature of the two airmasses determines the January mean temperature and is shown to be different in the warm periods than in the cold periods. A double Gaussian curve is fit to the January temperature frequency distribution and changes in the mean and standard deviations of continental arctic and maritime polar air are related to winter temperature variation.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00

**complete abstracts cited under Poster Session, pp. 167-178*

P-17 (4-B-1)
Climate Change from a Chemical Engineering Perspective. ***Bruce R Peachey*** (New Paradigm Engineering Ltd., Edmonton, AB, Canada)

P-18 (4-B-1)
The Atmosphere Circulation andClimatic Changes in the North Atlantic and the Greenhouse Effect.
Kazimir V Kondratovitch, ***Natalie V Fedoseeva*** (The Russian State Hydrometeorological University, St. Petersburg, Russia)

4-B-2.1 10:30-11:45

Application and Evaluation of MC2 in Regional Air Quality Studies

Xin Qiu[1], ***Mike Lepage***[1], *Bradley J Snyder*[2], *Colin di Cenzo*[2]
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The Canadian Mesoscale Compressible Community (MC2) model has been applied to a series of regional air quality studies since 2002. The MC2 modelling provided high-resolution meteorological fields to be used to evaluate the impacts of Canadian and U.S. emissions, from man-made and natural sources, on ozone (O_3), fine particulate matter (PM2.5) and visibility within the Pacific Northwest (i.e., northern Oregon, Washington State, and most of southern British Columbia, including the major urban centres of Portland, Seattle, and Vancouver).

The study involved: preparation and conversion of the MC2 meteorological data for input into an air pollution emissions model known as SMOKE and an atmospheric chemistry/pollutant transport model called CMAQ; compilation and processing of emission inventory data, and air quality modelling over nested 12 and 4-km grid resolution domains for two meteorological episodes (summer 2001 and winter 2002). The model evaluation indicates that using the high-resolution MC2 model outputs to drive SMOKE and CMAQ resulted in good model performance on both grid definitions. On the other hand, an evaluation of MC2 profile data during the Pacific2001 Field Study and an undergoing MC2 sensitivity test study showed that the geophysical data (e.g., roughness length, topography, vegetation, etc.), the surface treatment scheme (force-restore vs. ISBA) and microphysics scheme used in the MC2 had considerable impact on the meteorological fields, which can be very important for the air quality study.

4-B-2.2 10:45-11:00

Using the MC2AQ Model to Study the Transport and the Back Trajectories of the Stable Carbon Isotope Ratios in the Oxidation of Hydrocarbons

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Different synoptic weather patterns advect the pollution originating from different sources. Studying the stable isotope ratio can be useful to understand the history of an air parcel, such as mixing and photochemical processing of hydrocarbons. The 3D model (MC2AQ) was modified (with two different resolutions: 21.2 km and 5.3 km) to include isotope information for Propene, Toluene, Propane, Benzene, Xylenes, and Isoprene. These compounds (both 12C and 13C) were included as tracers in the model reacting only with OH, with no feedback on the main chemistry. The kinetic isotope effect (KIE) was included for the reactions with OH.

The results show that there are not only chemistry effects but also the different weather systems have an impact on the carbon isotope ratio of those hydrocarbons. These affects are presented in two categories:

1) Chemistry effects: The 13C varies with emissions: when emissions are high the 13C is close to that of the sources, and as the air parcel moves away from the sources the 13C gets heavier due to the chemical processing. We see a clear diurnal pattern in the 13C after removing the effect of the sources. This is an indication of the effect of the processing by OH. The results

show that the vertical gradient of 13C depends on the lifetime and the KIE of the hydrocarbons. The model was also set up to study the effect of the different types of emission sources (area sources or point sources) of hydrocarbons on 13C. Using this method can help us to identify the fractionation and location of these two sources.

2) Meteorology affects: The back trajectories of the stable isotope ratio (13C) were determined to study the history of each hydrocarbon. The trajectories were determined for a few days with a stable weather pattern in July 1999. The results of the back trajectory of average photochemical age can also help in the determination of the possible sources of individual hydrocarbons and the effects of mixing and dilution during the parcel advection.

4-B-2.3 11:00-11:15

MC2 Simulations of Recirculation Processes in the Lower Fraser Valley (British Columbia)

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As it has been shown in many cases (Athens, Los Angeles, Vancouver), topographically induced mesoscale circulations can enhance air pollutant levels. In the Lower Fraser Valley (British Columbia, Canada), atmospheric motions are the results (in cases of low synoptic forcing) of the combination of mountain/valley winds (in the main valley as well as in the tributaries), slope flows induced by mountain ridges up to 2000 m height a. s. l., land/sea breezes, and channelled flows in the Georgia Straight between Vancouver Island and the Mainland. Such complex situation has been studied with a mesoscale atmospheric model (MC2) for few days of the Pacific 2001 field experiment (August 2001). To analyze the recirculation processes, several passive tracer releases have been modelled by emissions in the region of the city of Vancouver, close to the coast line (where the strongest emissions are located) for different periods of the day.

The analysis of the results shows the existence of three main recirculation processes: 1) a day-to-night recirculation, where tracers emitted during daytime and pushed inland by sea-breezes, valley winds and upslope flow, are transported back towards the coast by slope flows and mountain winds at night; 2) a night-to-day recirculation, where tracers emitted during night and pushed over the sea by land breezes, are brought back over land during daytime by sea breezes; 3) a day-to-day recirculation where tracers emitted during daytime are transported vertically by up-slope flows, and stored in a reservoir layer. Those tracers are then fumigated back to the ground the following day. The relative importance of these mechanisms will be also analyzed, as well as the impact of a small variation of the synoptic forcing on the balance of the three mechanisms.

4-B-2.4 11:15-11:30

Comparison of the GEM-HIMAP Precipitation Forecasts and Radar Nowcasts

Slavko Vasic, *Charles Lin, Isztar Zawadzki, Barry Turner*
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For short term prediction of precipitation (0-3 hours), nowcast methods based on Lagrangian advection of radar-retrieved precipitation offer the most robust and accurate results at mesoscale resolution, as the initial conditions are known accurately. However, with forecast lead time their skill (information content) deteriorates. For longer forecast lead times, numerical weather prediction models may perform better than nowcast methods, as they resolve dynamically the large scale flow and allow processes to evolve in time in accordance with imposed boundary conditions.

In this study, we compare conventional skill measures of the GEM-HIMAP model forecasts with radar nowcasts. We focus in particular on the cross-over point in forecast lead time where models would perform better than nowcasts. Two versions of the radar nowcast are considered: a straight unfiltered nowcast and a nowcast prepared using a "near-optimal forecast filter" (NOFF). NOFF is designed to optimize forecast correlation and root mean square error statistics through selective filtering of spatial scales based on a wavelet transform. The radar precipitation, taken from US radar composites, is used for verification. Our earlier comparison of the GEM and ETA models' precipitation results with radar-retrieved precipitation (performed in both physical and spectral space) for a 6-day rain event during May 24-30, 2001, showed satisfactory agreement between model and radar power spectra at the large scales. At the small scales, model results exhibit too rapid fall of power spectra in comparison with the radar spectra. The results of this study show that the model forecast has more skill than the radar nowcast after about 6 hours. Future work includes the blending of model and radar results to yield an optimal forecast.

4-B-2.5 11:30-11:45

GEM – Progress Report on the Next Generation Canadian Community Model

Sylvie Gravel, *Michel Desgagné, Vivian Lee*
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The Global Environmental Multiscale (GEM) is the atmospheric model used operationally by the Canadian Meteorological Centre (CMC) for short, medium-range, and ensemble forecasting. The model is also at the core of CMC's data assimilation system. In its original design, the model's domain was the sphere, and high-resolution regional simulations were done using a variable-resolution mesh for the horizontal discretization. A limited area version of the model is now also available, allowing for a more efficient approach to mesoscale modelling over a small domain. This new version of GEM, with its global, variable resolution regional, and fine scale limited area capabilities, is proposed as the future Canadian community model. Results from simulations at various scales, and with various configurations will be presented.

4-B-3.1 10:30-11:00 Invited

Double Diffusive Mixing in Shear-Driven Overturns

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The density of seawater is determined by two scalars, heat and salinity, that have very different molecular properties. This difference impacts ocean mixing through a number of interesting mechanisms that go by the general name “double diffusion”. Double diffusive mixing has been under investigation since the sixties, and is in many respects well understood; however, the interaction between double diffusive mixing and the more standard shear-driven turbulent mixing has received relatively little attention. This is a crucial issue because most regions of the ocean that are susceptible to one mechanism are also susceptible to the other. I will describe direct numerical simulations of breaking Kelvin-Helmholtz billows in a fluid susceptible to double diffusive effects. The resulting flows exhibit a complex combination of turbulence, gravity waves and double diffusive phenomena. When both thermal and saline contributions to density stratification are stable, turbulent diffusivities may differ by up to a factor of two. When one or the other contribution is unstable, double diffusive instability combines with shear instability to create entirely new mechanisms for the transition to turbulence. Understanding of these complex mixing effects is crucial for large-scale modelling and climate prediction.

4-B-3.2 11:00-11:15

Using Laboratory Measurements and Scaling to Estimate Upwelling due to Submarine Canyons

Susan E Allen[1], *Ramzi Mirshak*[2], *Barbara M Hickey*[3]
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Rotating stratified flow around steep three-dimensional topography poses a difficult problem in gfd but has numerous applications to the ocean and atmosphere. Because these flows are also difficult to simulate numerically, results from laboratory experiments and field measurements will be highlighted. We will look specifically at flow over a submarine canyon and consider the dynamics of flow counter to the slope wave-guide. In this configuration, the flow along the continental slope causes up-canyon flow. The source and role of the along-canyon pressure gradient in driving the upwelling will be reviewed. A scaling analysis gives the theoretical dependence on Rossby and Burger numbers for the depth of upwelling and flux of flow up the canyon. Laboratory measurements of the drag due to the canyon can be used to test the scaling of the latter. As the principal canyon drag is due to form drag even though large amplitude waves are generated downstream from the canyon, the drag can be directly related to flux up the canyon. Implications on the importance of upwelling through real canyons will be briefly presented.

4-B-3.3 11:15-11:30

Stability and Evolution of Dense Currents on Sloping Topography

Joshua T Nault, *Bruce R Sutherland, Gordon E Swaters, Kerianne Yewchuk*
Department of Mathematical and Statistical Sciences, University of Alberta, Edmonton, AB, Canada
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Driven by a need to understand the propagation and stability of abyssal ocean currents, there have been numerous idealized studies examining the dynamics in a rotating frame of reference of dense fluid on a slope underlying a less dense ambient fluid. This circumstance is characteristic, for example, of the Denmark Strait Overflow and the Western Boundary Undercurrent. A starting point of many theoretical and numerical studies is to assume the ambient is stationary and the current moves initially at a constant speed set by geostrophic balance. However, recent laboratory experiments (e.g., Lane-Serff and Baines, 1998) have shown that the continuous injection of a dense current from a localized source can significantly accelerate the ambient fluid and the consequent interaction between the two moving fluids cannot be neglected.

We have performed a series of laboratory and numerical experiments designed to examine the temporal as well as spatial stability characteristics of the current. In laboratory experiments a 90 centimetre diameter cylindrical tank on a rotating table is filled with fresh water. Dyed salt-water is injected uniformly through an annular slit on the conical-shaped bottom of the tank thus creating a uniform circular current. When instability occurs we observe a sinusoidal mode with phase speed approximately equal to that of the induced surface flow.

The results are shown to be consistent with barotropic instability of the ambient rather than baroclinic instability of the dense current. Indeed, numerical models that simulate the injection process capture the dynamics observed in the laboratory, whereas models initialized with a dense bottom current beneath stationary ambient exhibit qualitatively different (baroclinic-dominated) instability dynamics.

4-B-3.4 11:30-12:00 Invited

Meridional Flow of Source-Driven Abyssal Currents

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A hybrid 3-layer QG/PG model is introduced to examine the baroclinic evolution and meridional flow of source-driven abyssal currents over sloping topography. A number of important distinguished dynamical limits exist within the model such as the "Stommel-Arons," "Nof abyssal" and the "planetary shock wave" balances. A novel (i.e., ad hoc) southern boundary upwelling scheme is introduced, within the context of a closed basin with no-slip boundary conditions, to balance the northern source of abyssal water, thereby allowing the meridional transport of abyssal water to evolve toward a statistical steady state.

Numerical simulations exhibit initial southward motion in the source region (consistent with Stommel-Arons theory) and the rapid onset of vigorous baroclinic instability (consistent with the baroclinic instability theory we have previously described) followed by saturation and sustained equatorward motion consistent with a Nof balance. The "planetary shock wave balance" acts to

inhibit baroclinic instability and maintains western intensification within the abyssal flow. Of particular interest, strong surface intensified cyclones, similar to those observed in association with the Denmark Strait Overflow, are produced in the near source region. The cyclones are associated with the development of abyssal pulses within the abyssal current. Although the deep water production is modelled as steady, the numerical simulations exhibit, in the near source region, temporal variability on the annual and longer time scale. Moreover, notwithstanding the time variability seen in the simulations, the temporal average of the statistically steady part of the simulation reveals an abyssal flow not unlike that seen in deep western boundary undercurrents.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00

**complete abstracts cited under Poster Session, pp. 167-178*

P-19 (4-B-3)

A Physical Study of Upwelling Flow Dynamics in Long Canyons. ***Amy F Waterhouse****, Susan E Allen*
(Earth and Ocean Sciences, Geological Sciences, University of British Columbia, Vancouver, BC, Canada)

4-B-4.1 10:30-10:45

Modelling Trapped-Fetch Waves with Hurricanes

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Trapped-fetch waves with tropical cyclones have a single dominant spectral mode: in the direction of storm motion. Accordingly, single spectrum wave generators, analogous to first generation wave growth equations, are sufficient for producing accurate wave height forecasts as long as the wind forecasts are of high quality. Refinements of the Canadian Hurricane Centre (CHC) parametric hurricane wind model (PHWM) have made available higher quality wind fields, both for forecasting and hindcasting. As well, refinement of the CHC trapped-fetch wave model (TFWM) – driven by the PHWM – has afforded greater success at capturing the largest trapped-fetch waves with tropical cyclones. The PHWM runs on a Linux platform forecaster workstation, allowing for forecaster intervention in the hurricane parameters. Following intervention, the TFWM can be rerun to generate new wave trajectories that incorporate the refined storm parameters (such as track, wind speed, and central pressure). Operational runs to generate maximum possible wave heights and trajectories for each hour throughout a storm's history, or forecast, take a maximum of 45 seconds. This gives the operational advantage of being able to make storm parameter adjustments close to a bulletin deadline, thereby affording a confident prediction of storm-waves resonance to be available for consideration prior to issue time. This presentation will highlight the model and will demonstrate its utility by showing operational output for some 2003 Atlantic tropical cyclones as well as select storms from the recent past.

4-B-4.2 10:45-11:00

A Hurricane Climatology for Canada

Peter Bowyer[1], *Lorne Ketch*[2]
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The recent decadal upswing in Atlantic hurricane activity dictated a need to understand the realistic threat of hurricanes in Canada. Funded by the National Search & Rescue Secretariat's New Initiatives Fund, the Canadian Hurricane Centre developed a comprehensive climatology of hurricanes for Canada and her territorial waters in order to quantify the threat. This two-year project was broken in 4 components:

1. Development of a static 100-year climatology (1901-2000) of tropical cyclone frequency based on strength for each province, main city, and marine forecast area (based on the US National Hurricane Center's HURDAT data set).
2. Development of a powerful interactive web-based climatology for use by forecasters, researchers, or the general public.
3. Extension of the extratropical phase of all post-1949 NHC HURDAT storms that tracked through Canada of her waters.
4. Conduct a newspaper search of major eastern Canadian newspapers, cataloguing reported impacts of tropical cyclones in Canada.

The climatology will be introduced along with the web-based application.

4-B-4.3 11:00-11:15

An evaluation of Precipitation Distribution in Landfalling Tropical Cyclones

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Often, precipitation forecasts associated with landfalling tropical cyclones are based on a simple algorithm where the maximum 24-h precipitation (in inches) is forecast by 100/v, where v (in m.p.h.) is the translational speed of the cyclone. This algorithm, however, provides little insight as to the precipitation distribution and intensity that can be expected in a land-falling tropical cyclone. Furthermore, several recent cases (Danny, 1997; Dennis, Floyd, and Irene, 1999) show that precipitation distribution and intensity can be drastically altered by interactions with mid-latitude troughs and jet streaks which often result in extratropical transitions. Occasionally, these interactions produce catastrophic rainfalls as illustrated by hurricane Floyd in September 1999. This talk will present diagnostics of results from case studies and composites of several storms from a Quasi-Geostrophic potential vorticity (PV) perspective, designed to elucidate the important dynamics responsible for the modulation of the precipitation distribution and intensity.

Preliminary results suggest that precipitation distribution in land-falling tropical systems may be characterized in the following ways:

1) Precipitation is heaviest along/very near the track of a storm when there is no significant interaction with a midlatitude trough;
2) Precipitation distribution is heaviest to the right of the track of the storm when downstream intensification of the ridge is important; and,
3) Precipitation distribution is heaviest to the left of the storm track in a transitioning storm.

Without large scale forcing for vertical motion associated with a midlatitude trough in situation 1, most of the greater vertical velocities remain near the storm core in the region of greatest diabatic heating and maximum wind speeds. In situation 2, the intensification of the downstream ridge ahead of a weak midlatitude trough can accentuate the PV gradient between the tropical system and the downstream ridge, enhancing the cyclonic PV advection (implied ascent). In a transitioning cyclone (situation 3), a midlatitude trough approaching the tropical cyclone from the northwest often results in a strong baroclinic between the two systems. Once the tropical cyclone interacts with the baroclinic zone, a large region of precipitation develops in the left front quadrant of the storm in a region of strong warm air advection. Furthermore, diabatic heating from the resulting precipitation can re-distribute PV in the midlatitude trough creating a more dynamically active system with a negative tilt.

4-B-4.4 11:15-11:30

Space Time empirical normal Modes Diagnostic in Hurricanes

Yosvany H Martinez*, Gilbert Brunet, Man K Yau*
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We have developed a theory of Space Time Empirical Normal Modes (ST-ENMs) as a diagnostic tool to extract dynamically relevant space-time patterns in large datasets. ST-ENMs is a generalization of ENMs with space – time dependent bases that are dynamically relevant as they are derived from a physically based scalar product like wave activities. The theory of ST-ENMs in a window length corresponding to 1 h was applied in a diagnostic study of wave behaviour in a simulated hurricane and the results are consistent with those obtained in previous works using the ENM method for the same case study.

It was found that the wave activity spectra for wavenumber 1 and 2 are sign changing and separate the leading Vortex Rossby Waves from the noisy gravity waves. No unstable modes were observed. The ST-PCs (Space Time Principal Components) for wavenumber 1 and 2 obtained from the ST-ENM method are smoother and more monochromatic than the PCs obtained from the ENM method for the same wavenumber. This result suggests that the former represent better bases for flow decomposition. In addition, the identification of propagative patterns becomes easier using ST-ENMs. Analysis of the Eliassen – Palm (EP) fluxes and its divergence, which describe the dynamical evolution of the regions in which wave-mean flow interaction takes place, will also be presented.

4-B-4.5 11:30-11:45

Atmosphere and Ocean Modelling of Extratropical Transition

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Atmospheric and oceanic models are used to study the transition of hurricanes into extratropical cyclones in the mid-latitudes. This process is known as extratropical transition (ET) and is a major forecast challenge on the East Coast of Canada. The Mesoscale Compressible Community (MC2) model is used to simulate the ET of Hurricane Michael (2000) and Hurricane Juan (2003) using a synthetic hurricane vortex (Kurihara) approach for model initial conditions following the work of McTaggart-Cowan and Gyakum. Various sea surface temperature patterns are used for the surface boundary condition in the atmospheric model to study the impact on the storm. The Family of Linked Atlantic Model Experiments (FLAME) ocean model is used to study the ocean response to Hurricane Juan using both prescribed and simulated atmospheric wind forcing. A summary of the project and results to date will be presented at this talk.

4-B-5.1

10:30-11:00
Invited

Uncertainty and Probability Analysis for Long-Term Drought Climate – based on Tree-Ring Chronologies from the Central Prairies

***Ge Yu**, Dave Sauchyn*
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Drought in the Great Plains of the North America had serious and damaging effects on human society in the 20th century. The worst drought conditions of the past several hundred years are recorded in tree-ring chronologies. Tree-ring records from the Cypress Hills and Bear Paw Mountains provide high-resolution climate for the last 250 years and are a good climate proxy to examine long-term frequency of drought events, detect drought magnitudes more severe than gauge records, and estimate probabilities and uncertainty for predictions of future extreme climate.

From the analysis of reconstructed precipitation series, we obtained the following major results:

1) Two reconstructed drought periods, the 1930s and 1960s from lowest 10th percentile of 10-yr running average precipitation, can be validated by the gauge records. Applying different drought criteria (lowest precipitation, 1st, 10th percentile and 20th percentile) produces different results, suggesting that drought severity be defined by certain drought criteria for the purpose of limiting uncertainty.
2) Using Monte Carlo simulation, to obtain error-added reconstructions of precipitation, allow us to estimate the probability that precipitation in any reconstructed year or group of years was lower than the record-low gauge precipitation.
3) When n-year running averages are used to identify drought persistence, long-duration droughts occur earlier in the record than droughts of shorter duration. Shifts occur from long to short droughts in 1882 for the 2-yr running series, 1879 for 5-yr, 1855 for 10-yr and 1850 for 15-yr. This suggests that long-term climate records from tree-ring chronologies can reveal for longer drought (length > 250 years) than the short gauge records (length < 100 years).
4) The conditional probability measures uncertainties in the yearly tree-ring chronology that were created by varying sample size. It gives more chance of extreme drought events and reduces the probability of the normal event, providing more robust analysis in drought climate
5) Power spectrum analysis shows some climate cycle at 20~25-yr and 10~13 yr timescales in June-July precipitation for the Cypress Hills and at 17~19-yr and 10~13 yr timescales for annual precipitation in the Bears Paw Mountains.

4-B-5.2

11:00-11:15

An Assessment of Statistical Downscaling Methods for Generating Daily Precipitation and Temperature Extremes in the Greater Montréal Region

***Tan-Danh Nguyen**[1], Van-Thanh Van Nguyen[1], Philippe Gachon[2], Alain Bourque[2]*
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Local scenarios of temperatures (maximum and minimum) and precipitation at the daily scales are frequently required for climate change impact analysis. Recently, statistical downscaling techniques have been used to generate scenarios for a local site from global climate data. These techniques can be used to generate future scenarios for a site employing future climate change scenarios simulated by a global climate model. Several downscaling methods have been proposed

in the scientific and technical literature. However, each downscaling method has its own advantages and shortcomings. It is therefore necessary to perform a rigorous evaluation of different downscaling methods in order to find the most suitable approach according to some specific study objectives and for the specific climatology of the particular region of interest.

In the present study, two popular statistical downscaling methods based on the Statistical Downscaling Model (SDSM) and the Stochastic Weather Generator (LARS-WG) Model were selected for testing their feasibility and adequacy in the simulation of daily time series of precipitation and temperature extremes for different sites located in the greater region of Montréal, Quebec. More specifically, these two models were judged based on their ability to describe accurately the observed characteristics of local daily precipitation and temperature extremes at four weather stations Dorval, Drummondville, Maniwaki, and McGill. Historical records available at these stations for the period from 1961 to 1975 were used for model calibration and data for the remaining period from 1976 to 1990 for validation purposes.

In general, based on numerical and graphical comparison criteria, it was found that both models were able to describe accurately the basic statistical properties of daily maximum and minimum temperatures at local sites. In particular, the SDSM model could provide more accurate simulation of daily minimum temperature series for winter's months as compared with the LARS-WG. However, none of these models appears to be able to simulate well the statistical properties of daily precipitation processes. Finally, in terms of model's practical advantages, the LARS-WG is relatively easy for use as compared with the SDSM since it requires a simpler calibration method for parameter estimation. The calibration of the SDSM is based on a complex and difficult process in order to able to establish successfully the good relationships between large-scale climate variables and the daily precipitation and extreme temperature characteristics at a local site.

4-B-5.3 11:15-11:30

Regressional Variance Correction Method for Interpolating Daily Precipitation Data

Samuel SP Shen[1], *Peter Dzikowski*[2], *Guilong Li*[3], *Darren Griffith*[4], *Zhaojun Wang*[5], *Huamei Yin*[1]
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A powerful and convenient hybrid interpolation method, called RVC (regressional variance correction), of retaining variances and using all the station data was developed by Shen et al. (2001) based upon simple mass conservation. The method interpolates the station data onto a dense network of grid points, then averages the grid-point values inside polygons, and finally corrects the variance of the polygon data. Their motivation was to generate a set of daily precipitation data on 149 Ecodistrict Polygons in Alberta Province, Canada, from the precipitation data observed at 927 stations unevenly distributed within the province. The interpolated data are used as an input to various soil quality models, such as EPIC (Erosion/Productivity Impact Calculator). A key criterion for the precipitation input is the precipitation frequency, i.e., the temporal distribution of precipitation. However, because most of days in Alberta are sunny and have zero precipitation, the conventionally interpolated data often have too low variance in both space and time. Before RVC was developed, a stochastic model, such as Cligen, was used to

generate daily precipitation data that have the same mean and variance as the real field. However, the randomly generated precipitation field does not precipitate on the same days as the real field and also cannot generate outliers, i.e., extreme storms or extremely long period of drought. This talk will explain the RVC method from the perspective of statistical regression and demonstrate why the interpolated data can fit both climate mean and climate variance.

4-B-5.4 11:30-11:45

Application of Downscaling Techniques for Assessing Climate Change Variability and Extremes in Atlantic Canada

Gary Lines, ***Mike Pancura***
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The climate of Atlantic Canada is varied, encompassing both coastal and continental regimes and influenced by several major ocean currents and mountain ranges. In order to best describe the expected climate change, variability change and projected change to extreme events for the region, climate change scenarios and climate variables must be developed on a regional, or even site-specific, scale. Two methods currently exist that would potentially provide this information, output from a Regional Climate Model (RCM) and statistical techniques to “downscale” climate variables from global climate models. Since the RCM capability for Canadian territory is presently being developed and output for Atlantic Canada is not readily available, statistical techniques were utilized to generate the downscaled climate variables for a specific region, which were then used to generate values for change in variability and extremes. The statistical downscaling technique utilized in this study was the Statistical Downscaling Model (SDSM) version 2.3.3 developed by Rob Wilby et al., King’s College, London. In this study, predictors from the Canadian coupled global climate model (CGCM1) were used to generate ensembles of downscaled climate variables that are applicable to 14 sites in Atlantic Canada.

The means of these downscaled ensembles became the projected values, out to year 2100, of temperature and daily precipitation thus describing one plausible future climate for Atlantic Canada. These ensembles were then analyzed for climatic variability, i.e. how the probability of extreme values varies between historical and projected climates. As well, Gumbel extreme value analysis (EV1) techniques were applied to maximum annual 24-hour precipitation amounts, providing a new database from which to estimate the projected frequency of occurrence (return periods). For example, at one Atlantic Canada site (Greenwood, Nova Scotia), the historical return period for maximum 24-hour precipitation amount of 100 mm is 50 years. By applying the EV1 technique to the mean of the downscaled ensemble for the 2080s at this site, the return period shortened by a factor of 5, i.e., to 10 years. Such results are similar to earlier work by Kharin and Zwiers (2000) but suggest an even more extreme future. Such values can provide extreme value hydrologic data useful to researchers and engineers working at a regional or site specific scale. The ensemble means were also used to generate extreme climate indices as defined in STARDEX, a European-based climate indices software product.

4-C-1.1 13:30-13:45

Comparison of Model Performances for Leading NWP Centres

Tom Robinson
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NWP model verification scores, prepared according to strict standards from the WMO`s Commission for Basic Systems, are computed and exchanged monthly by many of the world's leading Centres. A sample of the latest verification results from the CMC models will be presented, particularly as they relate to the latest developments in the models and/or assimilation systems.

These results will be compared against the performance of the leading foreign NWP Centres, including ECMWF, United States (NCEP), United Kingdom (UKMetO), Germany (DWD), and France (Météo-France). Verification scores against observations (radiosondes) for MSL pressure, height, temperature and wind fields and against analyses (each centre using its own analysis) for geopotential height, temperature and wind fields will be presented. The process of verifying NWP model quantitative precipitation forecasts (QPF) at the CMC will also be presented, along with the latest results and comparison between Canadian (GEM) and U.S. (ETA) regional models.

4-C-1.2 13:45-14:00

A Status Report on the Community Climate System Model (CCSM3)

Philip E Merilees
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On June 2, 2004, a new version of the Community Climate System Model will be released to the scientific community. This model will be released in a number of different configurations including a T85 with a 1 degree ocean, a T42 with a 1 degree ocean, a T31 with a 3 degree ocean and a finite-volume dynamical core version at 2x2.5 degrees with a one degree ocean. The T85 version is the main model used for simulation of the possible climate changes under different scenarios of GHG concentrations. The T42 is used for investigations of sensitivity to horizontal resolution and for climate experiments that can manage with lower resolution (and lower cost). The T31 version is mainly directed towards paleoclimate applications. The finite-volume dynamical core is designed to handle the transport of many chemical species and is expected to be used as the basic approach for coupled climate-chemistry models. All configurations of the model give climate properties that are different from previous versions of the CCSM.

There are some effects of the higher horizontal resolution that are apparent in the mean climate particularly at the higher latitudes. There is more heat transported by the atmosphere into the Arctic in the T85 simulation than the T42 leading to somewhat less ice and a somewhat different heat balance. It remains to be seen as to the effect on climate sensitivity to polar processes. In the southern hemisphere, the surface westerlies are farther south than in T42 leading to a stronger Antarctic Circumpolar Current. Other comparisons of simulated climates from the different configurations will be made and an attempt to provide a physical understanding of the similarities and differences undertaken.

4-C-1.3

14:00-14:15

A Look at the ECMWF ERA40 Reanalysis Dataset

Steven J Lambert
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This overhead projector based talk reports on various aspects of the recently available ERA40 reanalysis dataset. This dataset spans the 45-year period from September 1957 to August 2002 over a global domain from the surface to 1 mb. The analyses are evaluated by intercomparison with independent analyses and observation-based data. Particular attention is paid to surface temperature, mean sea level pressure, precipitation, and stratospheric data.

4-C-1.4

14:15-14:30

Experimental Assimilation of SSM/I Data at MSC

David A Anselmo, *Godelieve Deblonde*
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In recent years, the assimilation of satellite data into global weather prediction systems has had a significant positive impact on weather analyses and forecasts. This is especially the case over oceans and in the Southern Hemisphere where conventional observations are sparse. The Meteorological Service of Canada (MSC) now assimilates thousands of observations every day from select satellites in addition to conventional data. These include clear-sky brightness temperatures from the AMSU-A (temperature sounder) and AMSU-B (humidity sounder) microwave instruments aboard three of NOAA's polar orbiting satellites, and clear-sky radiances from two Geostationary Observing Earth Satellite (GOES) long-wave instruments. At MSC, extensive work has been performed in preparation of the assimilation of clear-sky brightness temperatures (Tb) over open water from the DMSP (Defense Military Satellite Project) Spectral Sensor Microwave Imager (SSM/I) instruments (i.e., F13, F14 and F15). Clear-sky observations from the SSM/I provide valuable information on column integrated water vapour and surface wind speed.

To evaluate the impact of adding SSM/I data to the assimilation system, a comparison of the analyses produced with and without SSM/I data is performed for the month of July 2003. The control experiment (i.e., without SSM/I data) has the operational configuration of the assimilation system. To determine the impact of assimilating SSM/I Tb, an independent data source (TMI-TRMM microwave imager brightness temperatures) is used to evaluate the analyses of humidity produced from the two experiments. Various statistical fields will be presented to highlight the results of this comparison.

4-C-1.5 14:30-14:45

Extension of 3D-Var to 4D-Var: Results from the Pre-Operational Assimilation System of MSC

Stéphane Laroche[1], *Pierre Gauthier*[1], *Monique Tanguay*[2], *Simon Pellerin*[1], *Josée Morneau*[3]
[1]Data Assimilation and Satellite Meteorology Division, Meteorological Service of Canada (MSC), Dorval, QC, Canada
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A 3D-Var assimilation system has been implemented at the Meteorological Service of Canada in 1997. Since then, substantial modifications have been brought to different aspects of the system (e.g., background-error covariances, addition of ATOVS radiance data, variational quality control, etc.). This paper presents a description of the strategy used to couple the 3D-Var and the Global Environmental Multiscale (GEM) model to obtain an incremental 4D-Var assimilation system in which the model and the 3D-Var components are kept as separate entities. The main benefit of this approach is to considerably simplify the development and maintenance of the codes of the modelling-assimilation system. The 4D-Var currently uses a 6-h assimilation window with all data currently used in the operational analysis. It has been cycled over several months and the results show a significant positive impact in all regions but particularly over the Southern Hemisphere. Thinning algorithms for asynoptic data (e.g., ATOVS, SATWINDS, AIREP) have been revised and this resulted in a considerable increase in the volume of assimilated data.

In this paper, a complete description of the incremental formulation of this 4D-Var will be presented with a particular emphasis on the impact of grid interpolations required to go from the Gaussian grid of the 3D-Var system to the Arakawa C-grid used in GEM. A case will be presented in which the increased resolution in the polar regions has caused a 4D-Var analysis to fail: this can be related to the violation of the Lipschitz stability criterion of the semi-Lagrangian scheme used in the GEM model.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00
**complete abstracts cited under Poster Session, pp.167-178*

P-20 (4-C-1)
Impact of a Background Error Covariance Model based on sensitivity Functions in a 3D-VAR.
Cristina Lupu[1], *Pierre Gauthier*[2] ([1]Université du Québec à Montréal, QC, Canada; [2]Meteorological Service of Canada (MSC), Dorval, QC, Canada)

4-C-2.1 13:30-14:00 Invited

Recent Developments in the Theory of Internal Gravity Wave Breaking

Gary Klaassen[1], *Len Sonmor*[2]
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Recent work has demonstrated that the periodic temporal and spatial oscillations of both rotating and non-rotating internal gravity waves, together with their slantwise parcel motion play an important role in their breaking. This work will be reviewed in the context of the traditional stability theory for parallel flows.

4-C-2.2 14:00-14:15

An Investigation of Internal Wave Spectra using Eulerian and Lagrangian Formulations

Len Sonmor[1], *Gary Klaassen*[2]
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[2]Department of Earth and Space Science and Engineering, York University, Toronto, ON, Canada
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Our incomplete understanding of physical dissipation processes within an internal wave field impacts on questions of mixing in both the atmosphere and ocean, with enormous dynamical ramifications in the case of the middle atmosphere. Efforts to solve the puzzle have centred on nonlinear interactions among internal waves, but the inherent complexity has hindered progress. Some recent publications have proposed that the complexity could be circumvented by using a Lagrangian, rather than Eulerian, formulation. We present results from a new numerical study based on equivalent nonlinear Eulerian and Lagrangian equations, which uses various wave spectra to investigate this proposition.

4-C-2.3 14:15-14:30

Internal Wave Tunnelling through Mixed Regions

Bruce R Sutherland, *Kerianne Yewchuk*
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The path followed by internal waves propagating through a fluid with varying stratification and background horizontal flow is often assessed by way of ray theory. In particular, this theory predicts that waves reflect from a level where the Doppler-shifted frequency of the waves equal the background buoyancy frequency. Thus, without more careful consideration of the limitations of ray theory, one might conclude that internal waves reflect from regions that are locally mixed (for example, due to wave breaking or double diffusive convection). In reality, if the mixed region is sufficiently thin, incident internal waves can partially transmit across it. We have performed laboratory experiments demonstrating internal gravity wave tunnelling and we have solved linear equations of motion to predict the transmission coefficient of internal waves across mixed regions. For waves with fixed horizontal wavenumber incident upon a simple 'N^2 notch' profile, in which the density profile is continuous, the maximum transmission occurs for nonhydrostatic waves with frequency $\Omega=N/\mathrm{sqrt}(2)$. For waves incident upon a mixed region with discontinuous density jumps on either flank (a mixed N^2 profile), we find the existence of a resonant coupling between interfacial and vertically propagating internal waves that permits perfect transmission even for finite-depth gaps.

4-C-2.4 14:30-14:45

The Effects of Moisture on Boussinesq Dynamics

Kyle Spyksma, *Peter Bartello*
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A shallow Boussinesq box model with moisture variables will be briefly reviewed. Its relationship with a traditional (dry) shallow Boussinesq model will be discussed. This talk will focus on numerical investigations of how moisture fields, especially liquid water, interact with the dynamics of the flow. These effects will be considered through two different studies in which the model's domain is a triply-periodic box of size (1 km)-cubed. We will present numerical results displaying the potential for interaction between slow-timescale potential vorticity modes and fast-timescale effects of liquid water. As well, a study on the effect of the water variables on the predictability of the flow will be presented, comparing the predictability of 'dry' and 'wet' flows through an ensemble of model runs.

4-C-2.5 14:45-15:15 Invited

Can Gravity-Wave Drag Parameterizations be Validated in GCMs?

John F Scinocca[1], *Charles McLandress*[2]
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The parameterization of the drag exerted by unresolved gravity waves is now an essential ingredient of any general circulation model (GCM) that seeks to model the troposphere, stratosphere, and mesosphere. A number of parameterizations have been developed to address this problem (e.g., saturation theory, Lindzen (1981); nonlinear Doppler spread theory, Hines (1991); nonlinear diffusion; Weinstock (1982); empirical saturation theory; Warner and McIntyre (2001), etc.). In principle, each approach differs only in its treatment of the turbulent breakdown and dissipation of the gravity waves. Debate within the community regarding the validity and appropriateness of each has been vigorous and ongoing.

In this study, we undertake a careful inter-comparison of two schemes (Hines, 1991 and Warner and McIntyre, 2001). Rather than address the issue of their relative validity, we ask the more practical questions: How does their response differ? And perhaps more importantly, does it really matter which scheme is used? We accomplish this by building the dissipation mechanism for each scheme into one parameterization so that no other factors such as differences in the assumed wave spectrum or model numerics enter into the comparison. Differences in the response to the application of each scheme are documented in offline calculations and fully interactive climate simulations. Our main conclusion is that such differences arise not from fundamental differences in the dissipation mechanisms themselves but more simply from systematic differences in the typical elevation of wave breaking. This is supported by supplementary experiments in which we demonstrate that the response to either scheme may be obtained by the application of the other if one makes parameter adjustments designed to cause a shift in the typical elevation of wave breaking. Consequently, it does not seem possible at present to use climate GCMs to validate the physical basis of current GWD parameterization schemes.

4-C-3.1 13:30-13:45

Aircraft Data from Rapidly-Moving Hurricane Juan South of Nova Scotia

Christopher T Fogarty[1, 2], *James Abraham*[3]
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Near midnight September 29, 2003, Hurricane Juan struck the Nova Scotia coastline just west of the capital city of Halifax as an 85-knot category-2 hurricane. The hurricane was moving very rapidly northward near 30 knots over 18°C sea surface temperatures. Significant damage from storm surge and wind was inflicted on the coastline near but mostly east of landfall. There were hundreds of thousands of downed trees, many occurring as large tree blow-downs in wooded areas due to localized extreme gusts. The hurricane spread a swath of wind damage as far north as Prince Edward Island. Rainfall amounts were uncharacteristically light for a hurricane - less than 35 mm - since the storm was moving so quickly and due to the lack of cloud/convection on the southern side of the storm. The Canadian Search and Rescue Secretariat have funded a two-year research project into Atlantic hurricanes affecting Canadian interests. The primary goals of the project are to collect data from tropical cyclones undergoing extratropical transition in order to better quantify the threats, as well as to improve the understanding of the structure and predictability of these systems. Two flights were conducted in the Fall of 2003 using the National Research Council Convair-580 aircraft: the first into the remnants of Hurricane Isabel over southern Ontario, and the second into Hurricane Juan just prior to landfall in Nova Scotia.

Data from the Hurricane Juan flight will be presented in this talk. There were two transects through the storm (two eye penetrations) at approximately 6500 m; one from north to south and the other from southwest to northeast parallel to the coast of Nova Scotia. Dropsondes were deployed along both legs, 11 along the north-south leg and 13 along the coastal leg. Vertical profiles of radar data were also collected from this flight. Wind data showed very strong deep-layered winds above the boundary layer on the east side of the hurricane, not unlike an earlier mission into Hurricane Michael in 2000. Very large wind shears in the boundary layer were observed with surface winds as low as 50% of the top-of-boundary layer winds. A large portion of the south side of the storm was void of convection and precipitation, possibly owing to dry air entrainment from over land. Thermodynamic data revealed a pronounced core of high equivalent potential temperature (350 K+) that appeared to tilt northward in the direction of increasing shear. Data available at http://www.novaweather.net/Hurricane_Juan.html

4-C-3.2 13:45-14:00

Hurricane Juan – the Storm and Its Impacts

Peter Bowyer[1], *Chris Fogarty*[1], *Jim Abraham*[2]
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At 12:10 a.m. ADT, Monday September 29, 2003, Hurricane Juan made landfall near Prospect, Nova Scotia. Juan arrived as a category 2 hurricane, ripped northward through the province at nearly 60 km/h, and arrived in Prince Edward Island as a category 1 hurricane. Juan has claimed the lives of eight individuals: two when trees fell on their motor vehicle, two fishermen near

Anticosti Island, three in a house fire speculated to have been started by candles used during the power outage, and one involved in relief work weeks after the storm. Hurricane Juan is the most damaging hurricane in over a century for Halifax, N.S. Hundreds of thousands of Maritimers in Nova Scotia and Prince Edward Island lost power (some for near 2 weeks), dozens of buildings lost roofs, and 100 million trees were blown down (1 million in the city of Halifax alone). Halifax's historic Point Pleasant Park was obliterated. This pictorial presentation will highlight the storm and its impacts on the two affected provinces.

4-C-3.3 14:00-14:15

Hurricane Juan – the Warnings and Public Response

Peter Bowyer
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On September 29, 2003 Hurricane Juan made landfall in Nova Scotia as a category 2 hurricane, remained strong enough to cross Prince Edward Island as a category 1 storm, and ultimately crossed the Gulf of St. Lawrence as a strong tropical storm. Despite Environment Canada warnings of record-level winds, record-level storm surges and water levels, power outages and tree blowdowns, few people were prepared for the disaster which ensued. This presentation will highlight the warnings and media lines issued by Environment Canada, some reasons why the public and the media were unprepared for the storm, and the provincial and municipal EMO responses to Hurricane Centre information.

4-C-3.4 14:15-15:00

Peggy's Cove – Freak Wave from the East?

Doug Mercer
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This talk summarizes a rapid survey of the coastal damage due to Hurricane Juan over the days immediately following the storm. The focus here will be on the relative importance of wave versus surge damage, concentrating on areas where wave damage was important, but also showing some of the more interesting surge events. We first discuss the evolution of the ocean wave state just before landfall. Then we show damage in regions of high and low wave activity, particularly Peggy's Cove and in St. Margaret's Bay. There are large sections of coastline there which have deep water very near the shore, which permits wave breaking very near and sometimes right onto the shore, and we review evidence that wave breaking and wave runup were the major mechanisms there. The harbour area and other areas in Peggy's Cove were flooded by successive waves over a 20 minute period within an hour before Hurricane Juan made landfall at 12:10 a.m., September 29, 2003. The unique aspect of the flooding was that, even though the harbour opens to the west into St. Margaret's Bay, the waves came over the land from the east. In fact, in order to reach the harbour they had to come onshore and move inland 2-300 m and climb a 5 m rise. They then had to go over a 2 m breakwater at the top of the rise before flowing down another 1-200 m into the harbour. We discuss how this could have occurred, the path taken by the water, and evidence for an extreme or freak wave that may have played a role.

4-C-3.5 14:30-14:45

The Good, the Bad, and the Ugly – Numerical Prediction for Hurricane Juan (2003)

Ron J McTaggart-Cowan[1], *John R Gyakum*[2], *Lance F Bosart*[1]
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The range of accuracy of the numerical weather prediction (NWP) guidance for the landfall of Hurricane Juan (2003), from nearly perfect to nearly useless, motivates a study of the NWP forecast errors on 28-29 September 2003 in the eastern North Atlantic.

Although the forecasts issued over the period were of very high quality, this is primarily because of the diligence of the forecasters, and not related to the reliability of the numerical predictions provided to them by the North American operational centers and the research community. A bifurcation in the forecast fields from various centers and institutes occurred beginning with the 0000 UTC run of 28 September, and continuing until landfall just after 0000 UTC on 29 September.

The GFS (NCEP), Eta (NCEP), GEM (Canadian Meteorological Centre; CMC), and MC2 (McGill) forecast models all showed an extremely weak (minimum SLP above 1000 hPa) remnant vortex moving north-northwestward into the Gulf of Maine and merging with a diabatically-developed surface low offshore. The GFS uses a vortex-relocation scheme, the Eta a vortex bogus, and the GEM and MC2 are run on CMC analyses that contain no enhanced vortex. The UK Met Office operational, the GFDL, and the NOGAPS (US Navy) forecast models all ran a small-scale hurricane-like vortex directly into Nova Scotia and verified very well for this case. The UKMO model uses synthetic observations to enhance structures in poorly-forecasted areas during the analysis cycle and both the GFDL and NOGAPS model use advanced idealized vortex bogusing in their initial conditions.

The quality of the McGill MC2 forecast is found to be significantly enhanced using a bogusing technique similar to that used in the initialization of the successful forecast models. A verification of the improved forecast is presented along with a discussion of the need for operational quality control of the background fields in the analysis cycle and for proper representation of strong, small-scale tropical vortices.

4-C-3.6 14:45-15:00

Storm Surge of Hurricane Juan – Problems and Modelling

Douglas G Mercer[1,2], *Jinyu Sheng*[2], *Richard J Greatbatch*[2]
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[2]Department of Oceanography, Dalhousie University, Halifax, NS, Canada
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On September 29, 2003, Hurricane Juan swept across Nova Scotia and Prince Edward Island, and was one of the most severe storms to hit Halifax in over 100 years. Waves and/or storm surge caused extensive damage. The surge potential was a major problem for forecasting because the GEM model did not forecast the hurricane correctly, and this model drives the storm surge model used by the Maritimes Weather Centre (MWC) and the Canadian Hurricane Centre (CHC).

This talk briefly summarizes the storm surge damage done, and how the CHC forecasters came up with a reasonably good forecast despite the lack of model guidance. We decided to model the passage of Hurricane Juan over Canadian waters using a simple parameterized atmospheric model, where the parameters are those predicted operationally by CHC forecasters.

The storm surge model used was the operational model modified to resolve rapidly moving and intense small systems (i.e., Tropical Cyclones). Simulations were done at a resolution of $1/30^{th}$ of a degree for the Maritimes forecast region, and at $1/240^{th}$ of a degree for some coastal regions including Halifax. It was found that nearshore bathymetry and high model resolution were critical to properly estimate the surge. Nested modelling of storm surge, including operational implications, will be discussed. The storm surge had several features unusual in Atlantic Canada.

For the coast near Halifax the main response was due to the direct windstress and was amplified significantly by some inlets with shallow bathymetries. The response to atmospheric pressure was second, and there was a significant non-isostatic response. The response to rotation was minimal in this case during the passage of the storm, mainly because of the small size and rapid motion of the system. In the southern Gulf of St. Lawrence model showed the storm generating a barotropic wake due mainly to non-isostatic pressure forcing. The importance of, and past and future impacts of such wakes will be discussed. There was also a strong signal both observed and modelled in the Northumberland Strait near Prince Edward Island.

Session 4-C-4
Aviation Meteorology IV – Science Transfer and Training
Beaujolais Room/salle, Chair/chaise: ***Steve Knott***

4-C-4.1 13:30-14:00 Invited

Distance Learning Aviation Courses – What's New and What's Coming from the COMET® Program

Vickie Johnson
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In 2003, the Cooperative Program for Meteorology Education and Training (COMET) launched its first course geared specifically toward aviation forecasters. Developed in cooperation with the U.S. National Weather Service, Meteorological Service of Canada, and the U.S. Air Force and Navy, the Distance Learning Aviation Course 1: Fog and Stratus Forecasting was originally designed as a set of self-paced modules (available to anyone) and three teletraining lessons presented to only National Weather Service (NWS) staff. After receiving good reviews from the NWS forecasters, we are converting the teletraining sessions to self-paced modules, which will be available (along with the 8 self-paced modules in the original course) to all on the COMET Program's education and training Website, MetEd (http://meted.ucar.edu/).The course contains the following modules:

- Fog/Stratus Forecast Approaches (previously a teletraining session)
- Radiation Fog
- West Coast Fog (optional)
- Synoptic Weather Considerations
- Local Influences on Fog and Low Stratus
- Assessing Climatology in Fog/Stratus Forecasting
- Applying Diagnostic and Forecast Tools
- Case Study: New England Fog Event (previously a teletraining session)
- Customer Impacts
- Writing Effective TAFs
- Case Study: Northern Plains Fog Event (previously a teletraining session)

The individual modules have quizzes associated with them, and students can earn a certificate of completion for each quiz passed. In addition, when all of the required course components are finished, the student receives a course certificate of completion. To date, approximately 200 NWS students have completed the course. In addition to the fog and stratus forecasting course, the COMET Program is currently working on DLAC2—a course on aviation forecasting for convection. This course is expected to be finished in 2005.

4-C-4.2 14:00-14:15

The NorLatMet Case Study Library – a New Resource for Operational and Research Meteorologists

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The Meteorological Service of Canada became a sponsor of COMET - (Cooperative Program for Operational Meteorology Education and Training) in September, 2001. One result of this partnership was the creation of the NorLatMet Web site, which is dedicated to "Northern Latitude" meteorology (essentially, north of about 40N). One important recent addition to the site is the NorLatMet Case Study Library. Case studies are an ideal medium for connecting research

activities to operational forecast challenges. This two-way link guarantees that not only are such studies a highly effective learning tool for operational meteorologists, but also they are of great value to research scientists. The NorLatMet Case Study Library is designed to provide a "home" for various meteorological case studies, technical notes and research papers with a clear operational focus. Such works traditionally had limited distribution in the past in particular MSC Regions or Divisions scattered across the country, and so were usually restricted to a limited local audience. One goal of the new Library is to provide a framework to make such studies available to the wider meteorological community, in order to facilitate information transfer and reduce duplication of effort.

Although it is envisaged that the majority of the cases will be submitted by MSC meteorologists, the Library also encourages contributions from the academic community and others with an interest in northern-latitude meteorology. Furthermore, the Library is not restricted to Canadian-only content: international contributions are welcomed. The Library has a flexible design, so that submissions can be made in a variety of formats. A basic review of each study is expected, and a network of MSC reviewers who will do this for MSC contributors has been identified.

4-C-4.3 14:15-14:30

Local Area Knowledge: Requirements for Aviation Forecasting Across Canada

David Aihoshi*, Timothy Gaines, Edward Hudson*
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Contact: David.Aihoshi@ec.gc.ca

The Local Area Knowledge Project (LAKP) was researched by the Meteorological Service of Canada to provide manuals on weather, specifically local area knowledge and seasonal weather, for the seven aviation graphical forecast (GFA) areas of Canada. This work was funded by NAV CANADA and six manuals were produced to aid Flight Service Specialists (FSS) in weather briefings to pilots and to help give more detailed information regarding questions on the domain of the GFA's. For the Canadian Arctic, meteorologists went "north" and gathered information by interviewing pilots, dispatchers, Flight Service Specialists, National Park Wardens and others. The meteorologists also used information from fellow meteorologists, climate data, and existing studies. The presentation will give an overview of the project, how the research was carried out and how this information was used for the Canadian Arctic manuals. The focus will be on the field trips to Resolute and Iqaluit, Nunavut in the Canadian Arctic and the information gained there.

4-C-4.4 14:30-14:45

Aviation Meteorology – Developing a Community of Practice: a Model for Continuous Learning

David B Whittle*, Mary Qian, Aaron McCay, Russ Higginson, Daryl Pereira*
Canadian Meteorological Aviation Centre–West, Edmonton, AB, Canada
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A brief overview of what's in the current literature about continuous learning. Using this knowledge a group of operational forecasters developed a model to support and foster a learning in a shift work environment. As most shift workers know, the operational forecast world can at times be quite disjointed, with irregular hours and shift work. Finding to time learn and/or re-learn is often difficult without support. The learning model developed in the Canadian Meteorological

Aviation Centre–West involves developing a learning plan for each forecaster and method of support to achieve the stated objectives of the plan. The model presented is one which covers the COMET NWP Distant Learning Course.

4-C-4.5 14:45-15:00

Aviation Site Reference Web Interface for Operational Forecasters

Kyle C Fougere
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Recent announcements of restructuring of the Meteorological Service of Canada (MSC) have resulted in significant changes to the arrangement of aviation forecast production for NAV CANADA. In the past, 7 weather centers across Canada provided aviation services to NAV CANADA. These centers included Kelowna, Edmonton, Ottawa, Montreal, Rimouski, Quebec City, and Gander. The proposed restructuring will result in two centers for all of Canada; a Western Canadian Aviation Weather Centre (WCAC) based in Edmonton, and an Eastern Canadian Aviation Weather Centre (ECAC) in Montreal. The restructure will result in Edmonton continuing to provide aviation services for the Canadian prairies, the NWT and Nunavut with the addition of providing aviation services to new and challenging areas of British Columbia and the Yukon. In an effort to improve forecaster access to local area knowledge for the many terminal aerodrome forecast site responsibilities, a major effort was undertaken to assemble a variety of information for quick access by the forecaster when writing forecasts. This information includes topography maps, airport panoramas, monthly wind roses, various climatology charts and information gleaned from the NAV CANADA sponsored local area knowledge project. These products have been assembled into a web interface. Special attention was given to usability and forecaster navigation of the web site through feedback from Edmonton operational forecasters.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00

**complete abstracts cited under Poster Session, pp. 167-178*

P-21 (4-C-4)
Aviation Meteorology – Developing a Community of Practice: a Model for Continuous Learning.
David B Whittle, Mary Qian, Aaron McCay, Russ Higginson, Daryl Pereira, ***Andy Yun*** (Canadian Meteorological Aviation Centre–West, Edmonton, AB, Canada)

P-22 (4-C-4)
A Doppler Radar Interactive Tutoring Program: "S.V.R." ***Anke Kelker****, Bruno Larochelle* (Canadian Meteorological Aviation Centre–West, Edmonton, AB, Canada)

P-23 (4-C-4)
Aviation Site Reference Web Interface for Operational Forecasters. ***Kyle C Fougere*** Canadian Meteorological Aviation Centre–West, Edmonton, AB, Canada

4-C-5.1 13:30-13:45

Flux and Turbulence Measurements at a Densely Built-up Site in Marseille – Heat, Mass (Water, Carbon Dioxide), and Momentum

C Sue B Grimmond[1], *Jenny A Salmond*[2], ***Tim R Oke***[3], *Brian Offerle*[1], *Aude Lemonsu*[4]
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[2]School of Geography, Earth and Environmental Sciences, Division of Environmental Health and Risk Management, University of Birmingham, United Kingdom
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Eddy covariance (EC) observations above a densely built-up area in the centre of Marseille, during a summertime measurement campaign (ESCOMPTE) extend current understanding of surface atmosphere exchanges in cities. The instrumental array presented opportunities to address issues of the representativeness of local-scale fluxes in urban settings. Separate sets of EC systems were operated at two levels and a telescoping tower allowed this pair to be exposed at two different sets of heights. Path-averaged sensible heat fluxes were also available from two pairs of scintillometers. Here, the flux and turbulence observations taken at the four heights, stratified by wind conditions (Mistral wind and sea breeze), are used to address issues of the partitioning of the surface energy balance (SEB) in an area with large roughness elements. The turbulent sensible heat flux dominates in the daytime, although the storage heat flux is a significant term which peaks before solar noon. The latent heat flux is small but not negligible.

Observations of carbon dioxide fluxes reveal that this area is almost always a source, but the vegetation plays a role in the afternoon to reduce the magnitude of these fluxes. The scintillometer results show close agreement to the EC measurements. The atmosphere in such a heavily developed district is rarely stable. The turbulence characteristics support the empirical functions proposed by Roth (2000).

4-C-5.2 13:45-14:00

Parameterization of the Surface Radiation Budgets of Urban Areas

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The surface radiation budgets of urban terrain have been little studied. There are almost no standard observing stations in cities that even report incoming short- or longwave radiation fluxes and certainly none for outgoing or net radiation fluxes. This is an impediment to several potential applications including meteorological pre-processors used to calculate sensible and latent heat fluxes, atmospheric stability and mixed layer depth for use in urban dispersion models and the validation of mesoscale flow, climate and air quality models that are the precursors of a new generation of fine-scale meteorological forecast models for cities.

Through our own and joint international field campaigns we have gathered measurements of the component surface radiation budget fluxes at urban sites in different climates and with different surface structure and cover. Cities include Basel, Marseille, Miami, and Vancouver. These data and ancillary meteorological observations are used to devise parameterizations for each flux and hence the net all-wave radiation. The least easily handled flux is the outgoing longwave the

variation of which depends primarily on the surface temperature, and this property is known to be strongly impacted by urban development (urban heat island effect). Using detailed observations at a densely built-up site in central Basel this term can be estimated using only air temperature and solar radiation. The performance of the parameterizations is tested using data from all sites. These relations can be applied in other cities where only solar radiation and standard meteorological variables are available.

4-C-5.3 14:00-14:15

Analysis of Turbulence in the Urban Boundary Layer at Night

JA Salmond[1, 2], *TR Oke*[1], *CSB Grimmond*[3], ***SM Roberts***[1]
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[3]Department of Geography, Indiana University, Bloomington, IN, USA
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Turbulent transport processes operating in the urban boundary layer play an important role in determining pollutant dispersion at a diurnal scale. However, few studies have focused on the analysis of turbulence in the weakly-convective nocturnal boundary layer (NBL) which frequently occurs over cities at night. To address this need, turbulent fluxes of carbon dioxide and sensible heat were measured above the city of Marseille, France, during the summer of 2001. Weakly convective conditions were observed in the NBL throughout the study period. This can be attributed to the release of sensible heat stored within the urban fabric.

Analysis of the turbulence time series reveals intermittent spikes of carbon dioxide concentration and air temperature superimposed upon more stable mean background values. In Marseille, carbon dioxide is primarily emitted into the urban canopy layer (UCL) from vehicle exhausts. Similarly nocturnal sensible heat fluxes may originate in the deep street canyons that are warmer than roof surfaces. It is therefore assumed that the spikes observed in the time series may relate to intermittent bursts in the fluxes of carbon dioxide and sensible heat from the UCL. This study uses wavelet analysis to examine the hypothesis that carbon dioxide concentrations can be used as a tracer to identify characteristics of pollutant and heat venting from street canyons into the nocturnal urban boundary layer (UBL) aloft.

Wavelet analysis is shown to be an effective tool for the identification and analysis of significant events and coherent structures within the turbulent time series. Results indicate that in the late evening there is strong correlation between the atmospheric structures observed in the air temperature and CO_2 time series. Evidence suggests the spikes observed above roof-level in the UBL are related to the intermittent venting of sensible heat from the warmer UCL. However, later in the night, local advection of CO_2 in the UBL, combined with reduced traffic emissions in the UCL, limit the value of CO_2 as a tracer of convective plumes in the UBL.

4-C-5.4 14:15-14:30

Fluxes of Atmospheric Carbon Dioxide over a Suburban Environment – Observations from Vancouver

CJ Walsh[1], *TR Oke*[1], *J Salmond*[2], *CSB Grimmond*[3]
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Atmospheric carbon dioxide concentration is increasing globally. Most studies on this topic have focused on surface-atmosphere CO_2 exchanges over relatively simple and homogeneous environments typically resolved by large-scale climate and general circulation models (e.g., forest, tundra, ocean, etc.), while the carbon budget associated with urban environments remains largely ignored. Although cities comprise only a small fraction of the global surface area, they are the location of many of the primary sources of anthropogenic CO_2 through vehicular, industrial and building emissions. Since urban areas are often characterized by microscale complexity and variable terrain, measurements of CO_2 fluxes from cities are rarely attempted. However, with the development of finer scale models that can increasingly resolve spatial variability and complexity, atmospheric CO_2 exchanges in urban environments are an increasingly pertinent area of study.

To address this void, a relatively long-term (August 2001 - December 2002) measurement study of atmospheric carbon dioxide fluxes was conducted in a fairly homogeneous suburb of Vancouver, British Columbia. Similar urban structure and cover extends at least 1.5 kilometers in all directions from the measurement tower and consists primarily of one and two-storey detached houses with vegetation (trees, shrubs, and grass) surrounding the buildings. Standard eddy covariance techniques were adopted: a Li-cor 7500 open-path infrared gas analyzer measured the relative densities of carbon dioxide and water vapour, and a Gill sonic anemometer measured the vertical, horizontal and crosswind components of wind at about 25 m above mean ground level. Covariance of the vertical velocity of wind with the concentration of carbon dioxide yields the flux of carbon dioxide between the surface and constant flux layer.

In order to characterize the pattern of atmospheric carbon dioxide fluxes from a local-scale suburban area, trends illustrating seasonal variations of carbon dioxide fluxes are discussed. In addition, diurnal flux signatures are demonstrated, with CO_2 fluxes related to prevailing wind direction and surface source areas.

4-C-5.5 14:30-14:45

The Effect of an August 2001 Russian Wildfire Smoke on $PM_{2.5}$ and Ozone in Alberta

Jianhua Shi[1], ***Randy Rudolph***[1], *Bill Hume*[2], *Brian Wiens*[2]
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Airborne air quality data were collected as part of a major field program in Fort McMurray AB. Data analysis indicated relatively high $PM_{2.5}$ concentrations during Aug. 9 to August 14, 2001. Satellite images strongly suggested the source of the particulate was smoke from a Russian wildfire. The analysis in this paper uses continuous ground-level $PM_{2.5}$ monitoring data at 8

stations in Alberta, $PM_{2.5}$ NAPS sampling data at stations in the Northwest Territories and particulate data collected from an aircraft near Fort McMurray to examine air quality impacts during this event. The impacts of the wildfire emissions included elevated $PM_{2.5}$ values and enhanced diurnal variation in ground level ozone at several sites across Alberta.

4-C-5.6 14:45-15:00

On Modelling the One-Dimensional Thermally Induced Slope Flows

Xiurong Sun*, Wensong Weng, Peter A Taylor*
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Several commonly used one and half-order turbulence closure schemes for the atmospheric boundary layer (ABL) are applied to simulate nocturnal drainage/ katabatic flows and anabatic/upslope flows with a one-dimensional model. In addition to the evolution and structure of mean wind and temperature, the vertical profiles of the turbulent variables, such as the turbulent heat and momentum fluxes, TKE (turbulent kinetic energy), turbulence length scale, and eddy diffusivity for momentum are studied. Results obtained with the different schemes, E-1, E-ε and its modified versions, and two versions of the q^{21} Level 2.5, are compared and discussed.

RELATED POSTER(s) – Ballrooms A/B, Monday 31 May, 17:30-19:00

**complete abstracts cited under Poster Session, pp. 167-178*

P-24 (4-C-5)

Investigation of an Urban Heat Island as Part of a Meteorological Instrumentation Course. *James Finney,* ***Loren White****, Markeitta Benjamin, Daniel Canales, Tushundra Conerly, Shari Dixon* (Department of Physics, Atmospheric Sciences, and Gen. Science, Jackson State University, Jackson, MI, USA)

P-1 (1-B-3)

Effect of Vessel Type and Platform Relative Wind and Wave Direction on the Comparison between Ship and Buoy Winds

Bridget R Thomas, *Val R Swail*
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Long term homogenous datasets of marine surface winds are required for climate analysis. Significant temporal changes, in the size and type of observing platform and in the method, have introduced inhomogeneities to databases of archived marine winds. Buoy winds are the standard for validation of numerical model and remotely sensed data, but they do not extend very far back, in terms of the marine climate data record. Some inhomogeneities between ship and buoy wind reports are due to factors (such as different anemometer heights) whose effects can be computed theoretically and compensated for. Other factors such as air flow distortion and differences in averaging technique are less well understood, and not easily predicted from theory.

This study attempts to identify some of these factors that are less well understood, and to quantify them using statistical techniques. We study the influence of vessel type, recruiting country, visibility, and the platform relative wind and wave direction on the reported wind speed. Data is primarily from tankers, container ships, and government vessels in Canadian waters, reporting near moored NOMAD buoys from 1988 to 1995 (with some west coast data from 1980 to 1988, also).

Comparing u10n buoy winds (adjusted to 10 m effective neutral) to u10n measured and Lindau-adjusted estimated ship winds, we find that the ship-buoy wind speed relationship is significantly dependent on the heading of the ship relative to the wind and seas, and on the vessel type. For estimated ship winds, it also depends whether it is night time or day time.

P-2 (1-C-2)

Seasonal Comparisons of Strong Western North Pacific Cyclones and the SST Anomalies Beneath Them.

Richard E Danielson[1], *John R Gyakum*[2]
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[2]Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, QC, Canada)
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Studies have long emphasized the importance of western ocean boundary currents and their strong sea surface temperature (SST) gradients to the development of mid-latitude cyclones (especially strong ones). However, they have also emphasized that the role of surface heat fluxes in cyclones is not well understood. Prompted by an unexplained atmospheric phenomenon over the North Pacific Ocean, called the midwinter storm track suppression, the hypothesis of a seasonal variation in the role of surface heat and moisture fluxes in small groups of strong western North Pacific cyclones is examined. Their net effect is examined using SST anomalies as a proxy. Composite SST anomalies are constructed for each cyclone group, where groups are defined only by the occurrence of events during midwinter or during the early and late cold season. Systematic differences in sea surface temperature anomalies beneath these two groups are interpreted as differences in preconditioning by the upper-oceanic mixed layer. Some supporting evidence of an upward influence is available in terms of sub-monthly sea level pressure variations and a comparison for two groups of western North Atlantic cyclones. It is suggested that the role of preconditioning heat fluxes in cyclones varies because of large-scale seasonal changes in baroclinicity (or more specifically, static stability) and in the role of the ocean as a local source of water vapour.

P-3 (1-C-2)

High-Resolution Marine Wind Retrieval using Synthetic Aperture Radar

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As weather prediction systems continue to encompass an increasing range of scales, there is a practical need to combine simulated fields with observations that are valid on these newly resolvable space and time scales. Surface wind fields over the ocean are highly variable on scales of a few kilometres and an accurate specification is important for a wide variety of applications. Considering their high horizontal resolution, synthetic aperture radar (SAR) measurements by RADARSAT-1 may be well suited for incorporation into a coastal data assimilation system. We explore the feasibility of combining SAR observations and high-resolution numerical simulations for coastal regions of eastern Canada.

In the context of a variational data assimilation approach, we consider the state and parameter estimation problems. The former relates to SAR measurements being a scalar quantity. This quantity is the radar cross--section, which occurs mainly by Bragg scattering from capillary waves, which in turn vary roughly with wind speed. Although some scenes contain boundary layer roll convection, which is a good indication of wind direction, such features are not always present and the retrieval of the wind field is often underdetermined. We also explore the parameter estimation problem, which relates to our interpretation of the marine radar cross--section itself. Following recent studies, we consider scattering mechanisms that may be modulated by the larger-scale gravity wave spectrum.

P-4 (1-D-2)

Initialization of a Pacific Ocean Data Assimilation Project

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In data assimilation one strives to determine an optimal set of corrections that, when applied to external forcing and initial conditions, improves the accuracy of the predicted state variables in comparison to observed values. One model available for ocean data assimilation is the Inverse Primitive Equation Z-coordinate (IPEZ) model created by Bennett and Chua at Oregon State University. We are currently developing a regional version of IPEZ for the North Pacific Ocean. An important part of the data assimilation process is to properly configure the forward (in-time) model to produce an initial "best-guess" of the state variables. The IPEZ data assimilation model uses a simplified version of the well-known Modular Ocean Model (MOM) as the forward-in-time model.

Our configurations of the forward model include the introduction of realistic external inputs (topography, surface forcing, stratification, etc.), representation of sub-grid scale processes, and treatment of open boundaries. We will discuss some effects of the before mentioned configurations on the forward model. In addition, computational costs and challenges associated with the project will also be briefly discussed.

P-5 (1-D-3)

Topoclimate and Microclimate in Salluit Valley (Nunavik): Impacts on Permafrost Surface Temperature
Topoclimat et microclimats de la vallée de Salluit (Nunavik): impacts sur la temperature de surface du pergélisol

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The Inuit village of Salluit is located in a steep-sided glacial valley, north of Ungava peninsula, in continuous permafrost zone. The local climatic environment of the valley (topoclimate) is composed of a patchwork of microclimates who affect thermal regime of upper permafrost. In various of these microclimatic sectors, ground surface temperature (2002-2003) was hourly measured using 15 micro-dataloggers set on the ground surface (5 cm deep) in land types representative of all topographical and ecological conditions encountered in the study site : direction and incline of the slopes, soil type, snow cover and wind exposition, vegetation and surface humidity. In addition, thermal impact of the village installations was studied using 3 more micro-dataloggers set under buildings and road embankment. Analysis of mean, minimum and maximum temperatures, freezing and thawing indexes (degree-days) and N-factors (ratio between thermal indexes of the ground and the air) allowed us to classify topographical and ecological factors in function of their impact on upper permafrost temperature.

Le village Inuit de Salluit est localisé dans une vallée glaciaire encaissée, au nord de la péninsule d'Ungava, en zone de pergélisol continu. L'environnement climatique local de la vallée (topoclimat) est composé d'une mosaïque de plusieurs microclimats qui affectent le régime thermique de la partie supérieure du pergélisol. Dans plusieurs de ces secteurs microclimatiques, la température de surface du sol (2002-2003) a été mesurée, sur une base horaire, au moyen de 15 capteurs thermiques (micro-dataloggers) enfouis sur le terrain (5 cm de profondeur) dans des endroits représentatifs de l'ensemble des conditions topographiques et écologiques du site orientation et inclinaison des pentes, nature du sol, couvert de neige et exposition aux vents dominants, végétation et humidité de surface. De plus, l'impact thermique des infrastructures du village a été étudié au moyen de 3 autres capteurs, enfouis sous des bâtiments et près d'un remblai de route. L'analyse des températures moyennes, minimales et maximales, des indices (degrés-jour) de gel et de dégel dans le sol, ainsi que des facteurs-N (rapports entre les indices thermiques dans le sol et dans l'air) a permis de classifier les facteurs topographiques et écologiques en fonction de leur impact sur la température au sommet du pergélisol.

P-6 (1-D-3)

Climatology of Adverse Weather Events in the Canadian Arctic

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Adverse weather can be a hazard to all human and animal life at all times of the year, particularly in the Canadian Arctic. Adverse weather can have any number of definitions, however, this study included ground blowing snow (BS), snow and blowing snow (SBS), blowing snow with other precipitation occurring (BSO), winds, fog, ice fog, freezing precipitation (i.e., freezing drizzle and/or freezing rain), and low ceiling heights (equal to or less than 1500 ft for aviation). A climatology of these adverse weather events was produced for 20 Arctic stations using hourly weather observations spanning each station's entire data record (as early as 1953) up to 2002.

The climatologies (probabilities and occurrence frequencies) are useful for operational meteorological applications, but also provide a general site-specific complete climatology of each station that can be used by

climatologists. The research also serves as a historical context within which to view the science arising from the International Canadian Arctic Shelf Exchange Study (CASES), a one-year field experiment in the Beaufort Sea (September 2003-2004) and future dedicated field experiments of the Canadian ArcticNet National Centres of Excellence (NCE) (2003-2010). This poster describes one station's partial climatology (Churchill, Manitoba, Canada) as an illustration and utility of the climatology that is available for other stations. The complete climatology from Churchill and the remaining stations are available from the primary author's institution.

P-7 (1-D-3)

Forecast Support to the Canadian Arctic Through-Flow Study, an Oceanographic Expedition to Nares Strait on the U.S. Icebreaker Healy, Summer 2003

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Summer 2003, Prairie and Arctic Storm Prediction Centre meteorologist Edward Hudson joined the U.S. Coast Guard icebreaker Healy in its voyage to Baffin Bay and through Nares Strait to the Lincoln Sea as part of the CATS (Canadian Arctic Through-flow Study) science team. The expectation and the reality of weather and ice conditions for the voyage will be shared. We found the region to be a lively playground for the mesoscale meteorologist. Weather "experiences" including a significant "hit" and a significant "bust" will be revealed. Oceanography and 'tourist' activity from the perspective of a meteorologist will be illustrated.

CATS http://newark.cms.udel.edu/~cats/ is a U.S. National Science Foundation sponsored 5 year study regarding freshwater fluxes through the Canadian Archipelago. Work is collaborative with American, Canadian and Japanese scientists.

P-8 (1-D-3)

Polar Lows and Forecasting

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At the Forecasting Division for Northern Norway in Tromsø, Norway, meteorologists have an ongoing project with an aim to increase the forecasting skill in Polar Low situations. The challenge is to make the best combined use of computer models, observations and the forecasters experience without significantly increasing the workload. A study of Polar Low incidents the previous four winters indicates that cold air outbreaks combined with an upper level cold trough were the most consistent circulation patterns. Further work will concentrate to alert the forecaster in those situations and to increase his/her ability to interpret model data, satellite images and observations.

P-9 (1-D-5)

Fire Determines the Surface Energy Balance of the Canadian Forest Mosaic

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The Boreal Ecosystem Research and Monitoring Sites (BERMS) in central Saskatchewan, Canada, is committed to a long-term, ongoing objective: to determine the ecosystem exchange of radiation, sensible and latent heat, and carbon dioxide in Canadian boreal forests. As members of BERMS and Fluxnet-Canada, we are focused in achieving these objectives in a chronosequence of post-fire Canadian boreal forest stands. We have been comparing a chronosequence of burned sites, ranging from about 3 to 26-years-old with three mature (70 to 120 years) sites.

Measurements indicate that the post-fire environment changes the energy partitioning, largely controlled by the type of vegetation that regenerates. This affects radiation exchange in both the short and long wave, and the partitioning into sensible and latent heat flux. The greatest differences occur between forests dominated by deciduous and coniferous vegetation, especially when a former coniferous stand is replaced by young deciduous vegetation following fire. Approximately 2 to 3 million ha of Canadian forest burn annually, which creates a mosaic of surface energy-balance characteristics on scales of a few to many thousands of hectares. It is difficult to estimate the magnitude of the effect that these surface energy-balance changes have on local and regional climates. However, some fires can be quite large, and climate change projections suggest that the area burned will increase in the future. Climate models need to consider these changes to the surface energy balance.

P-10 (1-D-5)

In Situ Air Quality Monitoring of Smoke from Prescribed Burns of Boreal Forest in the Mountains of Banff National Park, Alberta, Canada

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Prescribed burns were conducted in May and June 2003 in Banff National Park as part of a fire management and ecosystem renewal plan. The area to be burned was on the front ranges of the rocky mountains with up to 10,000 hectares planned in an area where no significant burning had occurred since 1923. The burns included a variety of fuel mixes (primarily coniferous) with varying slopes and exposures and also some areas with Mountain Pine beetle infestation. On five days, portable particulate samplers (MiniVols) were deployed at one or two locations per day, prior to ignition, where smoke was anticipated. At each location, pairs of quartz and zeflour filters were exposed. On four days, locations with deployed samplers had significant adjacent fire behaviour, and samplers received substantial exposure to intense smoke. The filters were analyzed for 65 elements using ICP-MS, for 7 anions using IC, and for 22 PAHs using GC/MS. The methodology, a summary of the results and a preliminary analysis is presented.

P-11 (2-B-2)

Sea Surface Salinity from Space: a Canadian Perspective

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Sea surface salinity signals in Canadian waters are large, both spatially in terms of horizontal gradients and temporally on seasonal and interannual time scales. Consequently, Canada should be able to usefully exploit remotely sensed SSS. The accuracy of the proposed satellite sensors are about 0.4 practical salinity units (psu) for a single pixel, single pass observation and about 0.1 psu for data averaged over space and time into standard products (200 km and 10 days). Salinity varies by at least 1 psu across Canada's Pacific and Atlantic continental shelves, a value at least twice as large as the largest expected errors. Similarly, the amplitude of the seasonal cycle exceeds 1 psu in many areas. Year-to-year variations are generally smaller, but still often exceed 0.5 psu. Spaceborne SSS mapping should provide significant benefits to Canada. From a scientific vantage point, it should provide important information for climate studies, both in terms of data for assimilation into numerical models as well providing observations in regions where historical data coverage is extremely poor. Similar considerations also apply to regional modelling activities. As well, benefits will accrue in the areas of fisheries management and environmental monitoring as workers gain access to data on a long-term, year-round basis never before possible. Under its Earth and Environment Applications Program, the Canadian Space Agency has funded the authors of this presentation to study developments in space-based remote sensing of sea surface salinity (SSS). The broad project goals are to define Canadian interests relative to various proposals for salinity satellites, to identify potential Canadian benefits, and to promote Canadian involvement in all aspects of SSS monitoring.

In this presentation we describe recent developments in the remote sensing of salinity and to place these developments in a Canadian context. In doing so, we address a number of issues are including:

- What significance does the routine remote sensing of SSS hold for Canadian science and resource management?
- What special issues must be addressed for SSS remote sensing in Canadian waters, which are generally cold, are fed by low salinity estuarine runoff, and are sometimes ice covered?
- What can Canada contribute to the remote sensing/physical-biological oceanographic community?

P-12 (2-B-5)

The Parameterization of Ice Crystals' Heterogeneous Nucleation in Climate Models: Comparison with Observation Taken during SHEBA

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Ice crystals play en important role in the atmospheres, either in by their role in the radiative budget of the planet, or by their influence on most of the precipitation in mid and high latitudes. In order to predict more precisely the effect of ice crystals on the climate and weather it is imperative that we better understand their formation and we improve the parameterization of ice nucleation in numerical climate models. The colon version of the NARCAM (Northern Aerosol Regional Climate Model) model is used with two different parameterizations for ice nucleation in order to simulate the observations of clouds taken during the SHEBA (Surface Heat Budget of the Arctic)

measurement campaign. Two ice nucleation schemes are compared: the simple and widely used Meyers et al. (1992) scheme and the more detailed Khvorostyanov and Curry (2000) scheme. The Khvorostyanov and Curry (2000) scheme has been used in a generalized aerosol distribution and subsequently with more direct aerosol information. The simulations cover one year over the Beaufort Sea.

P-13 (2-B-5)
Study of Mixed-Phase Clouds Structure with the Canadian Regional Climate Model
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The Canadian Regional Climate Model plus a microphysical scheme: two-moments microphysics with three hydrometeor categories (cloud liquid water, pristine ice crystals and larger precipitation crystals) is used to test the simulation in forecast mode using ECMWF data at 0.4 X 0.4 degree. We are zooming in on cirrus at higher resolutions (9, 1.8, 0.36 km). We are currently using the data set measured in APEX-E3, measurements of radar, lidar, passive instruments and interpreted microphysics for some flights (G-II, C404, B200). The radar and lidar data are available for high level cirrus. The south west of Japon is the flight region. The dates are March 20, March 27 and April 2, 2003. We first focus on the March 27 frontal system. We did a rigorous synoptical analysis for the cases. The cirrus at 360 m resolutions are simulated. The mixed-phase clouds structure and some similarities between model simulation and observations will be presented.

P-14 (2-C-1)
Aviation Meteorology – an Operational Approach to Forecasting Low Level Wind Shear
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An overview of what's in the current literature about low level wind shear will be presented. In addition, a description of an operational approach taken by some forecasters in the Canadian Meteorological Aviation Centre–West to forecast this aviation hazard. A few examples of low level wind shear as observed in the Mackenzie Valley will be given.

P-15 (2-D-2)
Unusual Precipitation Sequence: March 23rd, 2003 Case Study
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Rain, changing briefly to ice pellets and/or freezing rain, then snow followed by more rain was forecast for southwestern Nova Scotia for March 23rd, 2003 as a low pressure system approached from the west. Despite the unusual sequence, precipitation occurred as forecast on this date. Data for this case were collected and studied.

The most significant feature detected was a cold pool of air trailing the surface low pressure centre and extending vertically to accompany the upper low centre at the 500 hPa level. Existing literature was then searched for similar investigations and none were found.

Vertical profiles for this case were obtained and used as the basis for establishing criteria to search historical upper air data for dates of previous occurrences of comparable events. Flexible criteria were chosen to allow similar cases to be identified despite variations in depth of vertical layers or range of temperature values and, in addition, wind velocity ranges were broadened. Wider limits allow more radiosonde ascents that may have occurred spatially or temporally near similar low pressure systems, rather than directly through such relatively small structures, to be detected. Upper air data are used to identify air masses and, therefore, are deemed to be suitable for the initial step of this selection process. Surface data were downloaded for selected dates and used, along with maps and charts, to determine if cases identified were indeed similar.

Results, of an historical data search for similar events in this locale, support the view that the precipitation sequence that occurred, in association with a transitory low pressure centre having a cold column of air extending from the surface up to the 500 hPa level, was indeed a rare occurrence in this area.

P-16 (3-B-3)

Canadian Long-Range Ice Forecasting in Hudson Bay

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The Canadian Ice Service (CIS) currently produces seasonal forecasts of freeze-up and break-up conditions in the Canadian Arctic and the East Coast of Canada 3 months in advance using analog methods. Shipping companies, port authorities, the Coast Guard, and northern communities are asking for longer range ice forecasts (3-12 months) to help facilitate their planning needs. In response, CIS has founded a Canadian Long-Range Ice Forecasting (CLIF) research program. The focus of the program is on the development of statistical models that use a set of predictors or precursor events to generate ice forecasts. In the search for predictors, the lagged relationships between sea ice anomalies in Canadian Waters and large-scale atmospheric and oceanic variability will be elucidated.

In this presentation, the Canadian Long-Range Ice Forecasting research program will be introduced and initial results from Hudson Bay will be presented. The dominant modes of ice variability in Hudson Bay during spring break-up are isolated using EOF analysis. Correlation analysis is used to identify a set of predictors and the skill of a forecasting model based on simple linear regression is assessed.

P-17 (4-B-1)
Climate Change from a Chemical Engineering Perspective
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Climate change is about energy and water transfers between various components in the very thin layer of atmosphere and water that cover the Earth's surface. Since chemical engineers work with energy and mass transfer on a daily basis, they should be able to provide some insights into some of the issues and areas of uncertainty related to climate change observations and speculations. Discussion is encouraged for three main areas of uncertainty which include:

a) Human enhanced water evaporation sources and source characteristics. Water withdrawals for irrigation and power generation have increased dramatically in the last 50 years and are approximately equal to 5% of the water evaporated over land areas. The resulting increase in water vapour must impact regional water content above the emission sources and in regions downwind of the sources and may be responsible for the observed 2% increase in land precipitation. The volumes and characteristics of the anthropogenic emission sources are then key variables which should be utilized to analyze water flux on a regional basis.
b) Potential impacts of industrial water emissions on regional climate. Some published articles indicate trends that show work week impacts on rainfall and diurnal temperature ranges and even frequency of lightening strikes near industrial facilities. These studies should be expanded with suitable controls to determine the potential causes of the observed trends, rather than just assuming they are caused by GHG emissions or some unexplained effect of undefined aerosols.
c) Concerns about long term climate change and GHG analyses based on proxy indicators such as trace gas concentrations in ice core, oxygen isotope ratios and tree rings. Both CO_2 and methane are strongly absorbed by ice and form water hydrates if pressurized under cool conditions, so trace concentrations measured in gas bubbles in ice core are unlikely to be comparable to direct atmospheric measurements. Atmospheric oxygen isotope ratios are unlikely to remain constant over long periods of time. Tree ring growth is dependent on water and nutrient availability as well as CO_2 concentrations and temperature.

P-18 (4-B-1)
The Atmosphere Circulation and Climatic Changes in the North Atlantic and the Greenhouse Effect
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The time series of surface water temperature of the Atlantic Ocean were considered separately for three latitude zones: 75-60ºN, 60-30° N, 30-0°N. The warming of the tropical surface waters is observed during the XX century. In the same time, the surface waters of the moderate latitudes become colder in the North Atlantic. In addition, the time series of monthly air temperature and precipitation were considered on the Baltic region. The climatic changes in the Northern Europe demonstrate spring and winter warming and annual precipitation increase. Both the evaporation from the oceanic surface and the air-ocean energy exchange depend on the temperature differences between the ocean surface water and the surface air. In spite of the opposite trends of surface water temperature, the air-ocean temperature differences tend to increase in the tropical and moderate ocean zones in consequence of the trade winds weakening and the Westerlies increasing due to the Earth rotation speed decreasing. The warm winters and the precipitation rise in the North Europe were caused these processes. The greenhouse effect impact should be maximum in the polar and minimum in the tropical regions of the Earth causing the Westerlies

weakening. The opposite situation was shown in the moderate latitudes of the Northern Hemisphere during the XX century. Anthropogenic warming is only one factor of the recent climatic changes. Other factors are the secular solar activity changing, the long-term planetary rotation speed fluctuation, evolution of the Earth geomagnetic field and ozone layer, the large-scale ocean-air processes. One of the factors is also the Earth magnetic poles migration in Canada and the Indian Ocean.

P-19 (4-B-3)

A Physical Study of Upwelling Flow Dynamics in Long Canyons

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Long canyons are topographic features that are responsible for increased upwelling along coastal margins. Located between Vancouver Island and Washington State, Juan de Fuca canyon is a long canyon that begins at the continental slope and continues into the Strait of Juan de Fuca. In the summer, the surface current off the coast of Vancouver Island travels mainly southwards while the California Undercurrent, a current greater than 200m below the surface, travels northwards. This canyon is a conduit for significant nutrient flux to the Strait of Juan de Fuca and has been associated with seasonal upwelling onto the shelf. An eddy, visible at the surface, forms at the mouth of the Juan de Fuca Strait and is an area of increased plankton growth.

A physical model of this canyon has been constructed in order to understand the upwelling dynamics in long canyons. The physical model is spun up to an initial rotation rate and the flow is forced by increasing the rotation rate over the equivalent of one day. Flow visualization using dye and tracer particles aids in the determination of the strength and location of upwelling, the strength of the deep canyon vorticity, and the deepest depth of upwelling. Using images captured with a digital video camera, particles are tracked and velocities of particles at different depths are obtained. Upwelling onto the shelf is observed in both dye and particle experiments with deep-water upwelling occurring onto the shelf at the head of the canyon. Parameters from previous short canyon experiments are replicated and show that long canyons have increased upwelling under similar conditions. The Juan de Fuca eddy is observed in preliminary physical modelling experiments and, by carrying out further observations of this eddy, the evolution and strength of this eddy are examined.

P-20 (4-C-1)

Impact of a Background Error Covariance Model based on Sensitivity Functions in a 3D-VAR

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Covariance models are an integral part of data assimilation. The forecast error covariances used in a 3D Variational (3D-Var) data assimilation system are generally stationary and they don't take into account the flow configuration. The flow-dependency of error growth means that the presence of a small error in the initial state evolves dynamically according to the model's dynamics thereby introducing some error growth or damping depending on the local stability properties of the flow. In the presence of local dynamical instabilities, small perturbations in the initial state can result in large changes in a short range forecast. These errors appear in sensitive areas and it is important to increase the precision of the analysis in these areas to prevent error growth in the short-range forecast. The sensitivity functions use the adjoint of a numerical weather prediction model to characterise the change in the initial conditions that will lead to an important modification in the short-term

forecast (within a 24 to 48h range). In this study, we are using a technique proposed by Hello and Bouttier (2001). In this approach, sensitivity functions are introduced as structure functions within the background error covariance matrix to allow the assimilation to have a different behaviour only in the sensitive areas. The formulation of the technique is presented first, in a simple 1D-Var scheme and then, in the full 3D-Var operational system of the Canadian Meteorological Centre (CMC). The analyses obtained in this way are compared with respect to those of the operational 3D-Var and also with those obtained with the 4D-Var system now being tested for implementation at the CMC.

P-21 (4-C-4)

Aviation Meteorology – Developing a Community of Practice: a Model for Continuous Learning

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A brief overview of what's in the current literature about continuous learning. Using this knowledge a group of operational forecasters developed a model to support and foster learning in a shift work environment. As most shift workers know, the operational forecast world can at times be quite disjointed, with irregular hours and shift work. Finding to time learn and/or re-learn is often difficult without support. The learning model developed in the Canadian Meteorological Aviation Centre–West involves developing a learning plan for each forecaster and method of support to achieve the stated objectives of the plan. The model presented is one which covers the COMET NWP Distant Learning Course.

P-22 (4-C-4)

A Doppler Radar Interactive Tutoring Program: "S.V.R."

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The Canadian Meteorological Aviation Centre–West has developed a software tool to assist in training forecasters to fully exploit the capabilities of the newly expanded network of Doppler radars across Canada. This interactive tool was designed to simulate radar signatures, covering both Synoptic and Mesoscale Doppler velocity pattern interpretation. The Simulator of Velocity Radials (S.V.R.) was created by an Industrial Internship Program student from the University of Alberta. It was first used in Edmonton for the 2003 Meteorological Operational Internship Program and was recently used for a Mini Science Seminar catered to PAAWC operational forecasters.

P-23 (4-C-4)

Aviation Site Reference Web Interface for Operational Forecasters

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Recent announcements of restructuring of the Meteorological Service of Canada (MSC) have resulted in significant changes to the arrangement of aviation forecast production for NAV CANADA. In the past, 7 weather centers across Canada provided aviation services to NAV CANADA. These centers included Kelowna, Edmonton, Ottawa, Montreal, Rimouski, Quebec City, and Gander. The proposed restructuring will result in two centers for all of Canada; a Western Canadian Aviation Weather Centre (WCAC) based in Edmonton, and an Eastern

Canadian Aviation Weather Centre (ECAC) in Montreal. The restructure will result in Edmonton continuing to provide aviation services for the Canadian prairies, the NWT and Nunavut with the addition of providing aviation services to new and challenging areas of British Columbia and the Yukon. In an effort to improve forecaster access to local area knowledge for the many terminal aerodrome forecast site responsibilities, a major effort was undertaken to assemble a variety of information for quick access by the forecaster when writing forecasts. This information includes topography maps, airport panoramas, monthly wind roses, various climatology charts and information gleaned from the NAV CANADA sponsored local area knowledge project. These products have been assembled into a web interface. Special attention was given to usability and forecaster navigation of the web site through feedback from Edmonton operational forecasters.

P-24 (4-C-5)

Investigation of an Urban Heat Island as Part of a Meteorological Instrumentation Course

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Over the last several months the Jackson State University Meteorology Program has received private donations of several used automated portable weather stations. These are being incorporated into hands-on instruction for an undergraduate meteorological instrumentation course (MET 202). In order to give students an opportunity to work with basic observing instrumentation in the field on an issue of local relevance, weather stations will be placed at various locations within the metropolitan area of Jackson, Mississippi, as well as at a nearby rural site. This will allow MET 202 students the opportunity to look at basic spatial and temporal patterns of the urban heat island, as well as for students to consider microscale effects for representative siting of stations. For a few cases of interest, the surface observations will also be compared with satellite retrievals of surface temperature over the urban and surrounding rural areas and with official National Weather Service observations from ASOS and manual stations.

Youth Posters – CMOS Prize Winners
***Edmonton Regional Science Fair* – 17-18 April, 2004**

P-25 ***(First Place)*****: "Adventure in Snow"**
Alex van Zyl, Grade 6, Sir George Simpson School, St. Albert, AB, Canada

P-26 ***(Honourable Mention)*****: "Weather Forecast"**
Paige Wakefield, Grade 6, Sir Alexander Mackenzie School, St. Albert, AB, Canada

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Thank You – Merci
Your participation has led to a successful Congress!
Vôtre participation a réussi succès au congrès!

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