ISSN 1195-8898

CMOS BULLETIN SCMO

Canadian Meteorological and Oceanographic Society

La Société canadienne de météorologie et d'océanographie

October / octobre 2004 Vol.32 No.5

CMOS Bulletin SCMO
"at the service of its members
au service de ses membres"

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Cover page: The Canadian Arctic Shelf Exchange Study (CASES) is an international effort to understand the biogeochemical and ecological consequences of sea ice variability and change on the Mackenzie Shelf. The picture shown on the cover page illustrates this major effort of the CASES network including Canada and nine other foreign countries. To learn more, please read the article written by Barber and Fortier on **page 131.**

Page couverture: L'Étude internationale du plateau continental de l'Arctique canadien (CASES) contribue à l'effort de la communauté internationale dans la compréhension des conséquences écologiques et biogéochimiques du changement et de la variabilité de la glace marine sur le plateau de la Mackensie. L'image en page couverture illustre cet effort majeur du réseau CASES incluant le Canada et neuf pays étrangers. Pour en savoir plus, prière de lire l'article de Barber et Fortier en **page 131**.

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Canadian Meteorological and Oceanographic Society (CMOS)

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Executive / Exécutif

....from the President's Desk

CMOS friends and colleagues:

I hope you all had an enjoyable summer. In terms of CMOS activities it was good, and rather busy. The members of your Executive who are new, or are serving in different positions, have been pestering the more experienced members as we "take inventory" in preparation for upcoming activities.

Much of our attention has focused on the vision paper, "CMOS in 2003/2004 and its FUTURE", published for comment here in the CMOS Bulletin SCMO a year ago (Vol. 31, No. 5, October 2003, pp.127-139). It outlines our aims, current activities and structure, and goes on to suggest future actions and changes that should enable us to be more effective. Several of the suggestions relate to better addressing the interests of operational meteorologists and students, as well as other special groups in our fields. As a first step in that direction, there will likely be a survey conducted in order to identify the special interests and activities that they would support within CMOS.

The vision paper also mentions a need to improve our communications and outreach initiatives. Over the summer, CMOS press releases and announcements were prepared and distributed. Input was provided for a submission to the House of Commons Standing Committee on Finance that is being presented by the Partnership Group for Science and Engineering on which CMOS is represented. We will be looking for volunteers among you with experience in communications and promotions to reinforce our Executive in these important areas.

After following leads that emerged at the recent Congress in Edmonton, we now have a full slate of CMOS committee chairs, some of whom will be looking for additional committee members.

Our Vancouver organizers have been busy preparing for the 39th CMOS Annual Congress, May 31 – June 3, 2005 on the "*Sea to Sky*" theme. We should also be busy preparing our best work for presentation at the Congress and submission to our CMOS publications.

All of the above items leave us well poised for a busy and exciting year. They also will all need your continuing involvement and support in order to reach a successful completion. That's what it takes to keep a volunteer society vibrant.

Harold Ritchie
President / Président

Volume 32 No.5
October 2004 - Octobre 2004

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Printed in Kanata, Ontario, by Gilmore Printing Services Inc.
Imprimé sous les presses de Gilmore Printing Services Inc., Kanata, Ontario.

CMOS exists for the advancement of meteorology and oceanography in Canada.

Le but de la SCMO est de stimuler l'intérêt pour la météorologie et l'océanographie au Canada.

Letters to the Editor

5 August 2004

Subject: CMOS Bulletin for August 2004

I received my copy of the August 2004 (Vol.32, No.4) CMOS Bulletin SCMO a couple of days ago. This is perhaps the first time I have received the CMOS Bulletin SCMO in my mailbox on the day it was supposed to have been printed and distributed; August CMOS Bulletin received on August 1st!

Congratulations for an efficient production and for raising the profile of the CMOS Bulletin! I also read with interest the Citation you received from CMOS. Very well deserved indeed!

The present issue [August issue] has several interesting articles on a variety of topics; also, the letters on the continuing debate on climate change are of particular interest to me. You have certainly raised the profile of CMOS Bulletin SCMO by initiating the climate change debate by way of exchange of letters and information.

[I have recently attended] the Moscow Conference on Climate Change and the Kyoto Protocol as one of the dissenting scientists. It was a short and hectic but an enjoyable trip for me attending the conference at the Russian Academy of Sciences building in Moscow. The arrangements were excellent, with simultaneous English/Russian translation and hard copies of presentation material provided to every-one attending the conference. The first day of the conference was very long as presentations and discussions continued till about 7.30 PM in the evening.

Keep up the good work!

Madhav Khandekar
Markham, ON

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18 August 2004

Subject: Warren Forrester Obituary (Vol.32, No.4, p.107)

Many thanks for the copy of *CMOS Bulletin SCMO*. It was interesting to read about the many accomplishments of my uncle [Warren], some of which I knew, but many still unknown. The obituary of my uncle Warren added some more insight into his interesting life. Thank you for your thoughtfulness.

Bruce D. Forrester
Oshawa, ON

Books in search of a Reviewer
Livres en quête d'un critique

Climate Change 2001, Synthesis Report, Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change, by Robert T. Watson, Editor, April 2002, Cambridge University Press, Paperback Cover, 0-521-01507-3, $40.00US

The High-Latitude Ionosphere and its Effects on Radio Propagation, by Robert Hunsucker and John Hargreaves, Cambridge University Press, Hardback Cover, 0-521-33083-1, $140.00US.

Exploration of the Solar System by Infrared Remote Sensing, by R.A. Hanel, B.J. Conrath, D.E. Jennings, R.E. Samuelson, Cambridge University Press, Hardback Cover, 0-521-81897-4, $120.00US.

Coasts: Form, Process and Evolution, Colin D. Woodroffe, Cambridge University Press, Paperback Cover, 0-521-01183-3, $50.00US.

Weather Cycles: Real or Imaginary?, by William James Burroughs, Cambridge University Press, Second Edition, 2003, ISBN 0-521-52822-4, Paperback cover, $45.00US.

If you are interested in reviewing one of the above listed books, please contact the *CMOS Bulletin SCMO* Editor at bulletin@cmos.ca

Si vous êtes intéressés à faire la critique d'un livre listé ci-haut, prière de contacter le rédacteur du *CMOS Bulletin SCMO* à bulletin@scmo.ca

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85th American Meteorological Society Annual Meeting

Theme: Building the Earth Information System

San Diego Convention Center
San Diego, CA, USA

9 - 13 January 2005

For more information, please consult the web at
http://www.ametsoc.org

The Canadian Arctic Shelf Exchange Study (CASES)

D.G. Barber[1] and L. Fortier[2] (editors)

A. Aitken, K. Arrigo, E. Carmack, K. Conlan, S. Demers, M. Fortier, M. Gosselin, Y. Gratton, J. Hanesiak, D. Holland, G. Ingram, G. Lintern, C. Lovejoy, C. Michel, L. Miller, P. Minnett, A. Mucci, C. Nozais, M. Ringuette, P. Renaud, T. Papakyriakou, D. Scott, G. Stern, P. Taylor, J. Tremblay, B. Williams, W. Vincent and over 100 Canadian and international co-investigators (contributors)

Résumé (Traduit par la direction)

Le gouvernement du Canada a commencé récemment à revoir sa stratégie dans le domaine de la recherche polaire. Cette évolution est due en partie : a) au déclin précipité au cours des décennies de 1980 et de 1990 (Hutchinson, 2000) de la capacité du Canada à gérer la science polaire ; b) à l'évidence croissante qui montre que des changements significatifs dans l'océan Arctique, la glace marine, l'atmosphère et la lithosphère se sont déjà produits et qu'ils sont reliés aux changements et à la variabilité du climat (IPCC, 2001) ; et c) à la souveraineté dans l'Arctique et en particulier aux routes de navigation dans le nord du Canada qui deviendront au cours des prochaines décennies le sujet de conversation. En particulier, la glace marine est devenue un centre d'intérêt dans le rôle important que la glace joue dans la vie des Inuits, le développement industriel, le cycle biogéochimique et la productivité marine. Étant donné notre position géopolitique en tant qu'une nation industrialisée dans l'Arctique, il s'ensuit que le Canada devrait jouer un rôle de leader dans la compréhension des conséquences d'un changement environnemental de l'Arctique.

Afin d'atteindre cet objectif, le réseau de recherche de l'Étude internationale du plateau continental de l'Arctique canadien («CASES»), subventionné (2001-2006) par le Conseil de recherches en sciences naturelles et en génie (CRSNG) et sous la direction du Canada, contribue à l'effort de la communauté internationale dans la compréhension des conséquences écologiques et biogéochimiques du changement et de la variabilité de la glace marine sur le plateau de la Mackenzie. Étant donné son ampleur, l'initiative de «CASES» convoque une grande partie de l'expertise canadienne et étrangère en rapport avec l'océanographie de l'Arctique. Au Canada, le réseau comprend les chercheurs principaux de dix universités canadiennes, les quatre ministères du gouvernement canadien (Pêches et Océans, Environnement, Ressources naturelles, Défense) et le Musée canadien de la nature. La Garde côtière canadienne et l'Étude du plateau continental polaire fournissent l'essentiel de l'expertise logistique et maritime dans cet effort de l'étude de l'Arctique. Le réseau «CASES» a réuni cette expertise régionale complémentaire autour d'une équipe comprenant 42 chercheurs canadiens et plus de 50 experts de l'Arctique de neuf pays étrangers (États-Unis, Japon, Royaume-Uni, Danemark, Russie, Pologne, Norvège, Belgique, Espagne). Les partenaires canadiens qui ont contribué au financement sont les suivants : Pêches et Océans Canada, le Service météorologique du Canada, la Fondation canadienne pour l'innovation, et le Service canadien des glaces. Un financement international a été obtenu par chacun des 9 pays partenaires et surtout par la NOAA, la NASA et le Programme japonais en science polaire. Dans cet article, nous résumons la structure du réseau de recherche de «CASES» et nous rapportons les résultats préliminaires à partir des éléments du domaine de l'expérience. L'analyse des données a commencé et sera complété avant l'année 2007. Nous planifions la publication des résultats dans les prochains numéros de la revue ATMOSPHERE-OCEAN et dans d'autres revues de renommées internationales.

Introduction

The Government of Canada has recently begun to make strategic re-investments into polar research. This evolution is due in part to: a) a realization that Canada's capacity to conduct polar science declined precipitously throughout the decades of the 1980s and 1990s (Hutchinson, 2000); b) mounting evidence which shows that significant changes in the Arctic ocean, sea ice, atmosphere and lithosphere have

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Canada Research Chair in Arctic System Science, Director, Centre for Earth Observation Science, University of Manitoba, Winnipeg, MB.

[2] Professor Louis Fortier, Canada Research Chair (Climate and ice covered marine ecosystems)
Scientific Director of ArticNet, Director general of Québec-Océan
Department of Biology, Université Laval, Ste-Foy, QC

already begun and that these changes are connected to global scale climate variability and change (IPCC, 2001); and c) Arctic sovereignty and in particular shipping routes through Canada's north will come into question in the decades ahead. Sea ice in particular has become a focus due to the significant role ice plays in Inuit livelihood, industrial development, biogeochemical cycling and marine productivity. Given our geopolitical position as an industrialized Arctic nation, it follows that Canada should play a leadership role in understanding the consequences of a changing Arctic environment.

Toward this goal, the Canadian Arctic Shelf Exchange Study (CASES) Research Network was funded (2001-2006) by the Natural Sciences and Engineering Research Council (NSERC) of Canada. CASES is an international effort, under Canadian leadership, to understand the biogeochemical and ecological consequences of sea ice variability and change on the Mackenzie Shelf. Given its scope, the CASES initiative summons a large fraction of the Canadian and foreign expertise in Arctic oceanography. In Canada, the network includes Principal Investigators (PIs) from ten Canadian universities, four Federal departments (Fisheries & Oceans, Environment, Natural Resources, Defence) and the Canadian Museum of Nature. The Canadian Coast Guard and the Polar Continental Shelf Project provide the essential logistical and navigational expertise for an Arctic endeavour of this extent. The CASES Network has merged this complementary regional expertise into a team comprising 42 Canadian Arctic researchers and over 50 Arctic specialists from 9 foreign countries (USA, Japan, UK, Denmark, Russia, Poland, Norway, Belgium, Spain). Partner funding was provided by Canadian collaborators: Fisheries and Oceans Canada, the Meteorological Service of Canada, Canada Foundation for Innovation, and the Canadian Ice Service. International funding was contributed by each of the 9 partner countries and in particular through NOAA, NASA and the Japanese Polar Science program.

In this article we summarize the structure of the CASES research network and report on preliminary findings from the field components of the experiment. Analysis of field data has begun and will be completed by 2007. We plan to publish our findings in forthcoming issues of ATMOSPHERE-OCEAN and other internationally recognized journals.

CASES Objectives

The central hypothesis of the CASES scientific program is that *"the atmospheric, oceanic and hydrologic forcing of sea ice variability dictates the nature and magnitude of biogeochemical carbon fluxes on and at the edge of the Mackenzie Shelf"*. The primary role of this hypothesis is to focus the sampling approach and general methodology.

To frame the field investigations we have developed three postulates which evolve directly from our central hypothesis:

P_1: *The early and wide opening of the Cape Bathurst polynya will increase phototrophy, augment vertical and trophic carbon fluxes and increase the transfer and net sequestration of material to the deep basin.*

P_2: *A late and/or narrower opening of the flaw polynya will favor heterotrophy and the deposition and remineralization of allochthonous carbon and sediments in the delta, Lake Mackenzie and on the Mackenzie Shelf*

P_3: *Variability in physical factors forcing the timing of snow cover and ice melt will affect the relative importance of ice vs pelagic primary production and determine the temporal patterns of carbon export to greater depths.*

The strength of the network lies in our ability to examine the study area as a system, coupling physical, chemical and biological processes into an understanding of how variability in sea ice dictates changes in the marine cryosphere. The nine subgroups which make up CASES (Figure 1) are:

1. Atmospheric and Sea Ice Forcing of Coastal Circulation (**Ingram and Carmack**, PIs);

2. Ice-Atmosphere Interactions and Biological Linkages (**Barber**, PI);

3. Light, Nutrients, Primary and Export Production in Ice-Free Waters (**Demers**, PI);

4. Microbial Communities and Heterotrophy (**Vincent**, PI);

5. Pelagic Food Web: Structure, Function and Contaminants (**Deibel**, PI);

6. Organic and Inorganic Fluxes (**Hill**, PI);

7. Benthic Processes and Carbon Cycling (**Aitken, Conlan, Renaud**, PIs);

8. Millennial-Decadal Variability in Sea Ice and Carbon Fluxes (**Scott**, PI);

9. CASES modelling subgroup (**Arrigo, Hanesiak, Holland**, PIs).

Experimental plan

A central aim of the CASES field program is to study the fall and winter pre-conditioning of the Mackenzie Shelf/Cape Bathurst Polynya ecosystem by the minimum fall and winter discharge of the Mackenzie River, and its spring and summer development in response to the intense freshet and the variable ice break-up. Because the study area (Figure 2) cannot be reached from southern ports until August, the only possible way to achieve this is by over-wintering a research icebreaker in the area.

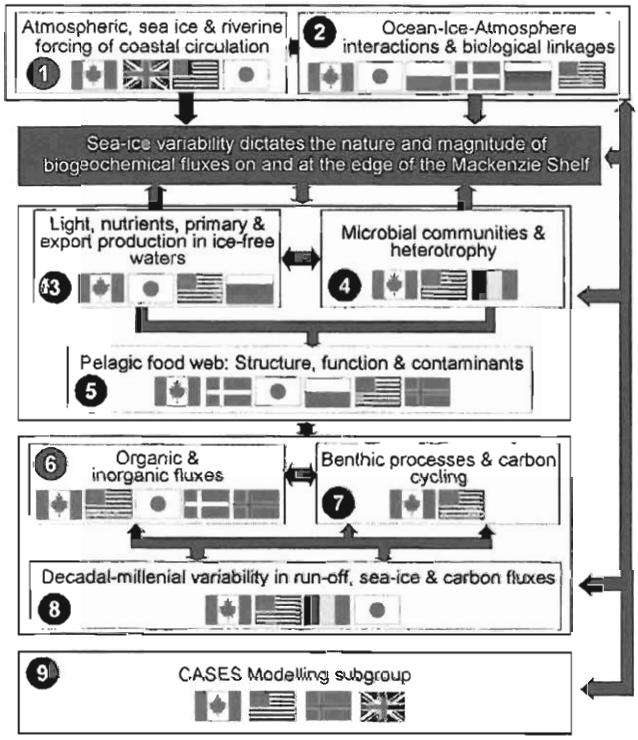

Figure 1. Nine subgroups of CASES with functional flow around the central hypothesis.

In preparation for this over-wintering, a preliminary expedition was conducted in September-October 2002 to moor current meters and sediment traps, deploy drifting buoys, and carry out ship-based biogeochemical sampling aboard the CCGS Pierre Radisson and the Laurier. The main thrust of the CASES program was the subsequent one-year over-wintering of the new Canadian Research Icebreaker the CCGS Amundsen (http://www.amundsen.quebec-ocean.ulaval.ca/) starting in September 2003 and ending August 25, 2004. During this annual cycle, the ship and landfast ice camps supported the year-round sampling of the shelf ecosystem. Ship-based sampling was conducted along a series of across shelf sampling transects (Figure 2) adjusted seasonally with the expansion-reduction of the open water (navigable) area. Satellite remote sensing coverage of the area was extensive with real-time data received on the ship to assist field operations.

This intensive field sampling program resulted in a 3-year interannual comparison of the ecosystem maturity in September, in response to ice cover variability, and for the first time ever, a year-round, highly integrated, multidisciplinary study of an Arctic shelf ecosystem coupled directly to the ocean, sea ice and atmospheric processes driving the marine ecosystem. The final experimental plan was adopted after consultations with the Inuvialuit communities that border this fragile ecosystem and the screening and licensing process from the local authorities. We also conducted community visits with the ship in each of the four Inuvialuit Settlement Region (ISR) communities in the area: Paulatuk, Hollman Island, Sachs Harbour, and Tuktoyaktuk (Figure 2). These visits included meetings with elders, presentation of science plans, results to date and discussions of local knowledge of changes evident to the members of these northern communities. We also conducted 'science days' by bringing kids of all ages from the communities to the ship for a demonstration of science in action.

The very successful pilot of the Schools on Board program (http://www.cases.quebec-ocean.ulaval.ca/school.asp) brought high school students from southern Canada together with kids from northern schools, teachers and administrators for an experiential learning project aboard the Amundsen and visits to local communities (Feb 23 to March 5, 2004). The students worked daily with all of the science teams aboard the Amundsen following a program which combined physical, biological, social and cultural aspects of climate change in the north. The program will continue as part of the ArcticNet Network of Centres of Excellence (NCE) Program.

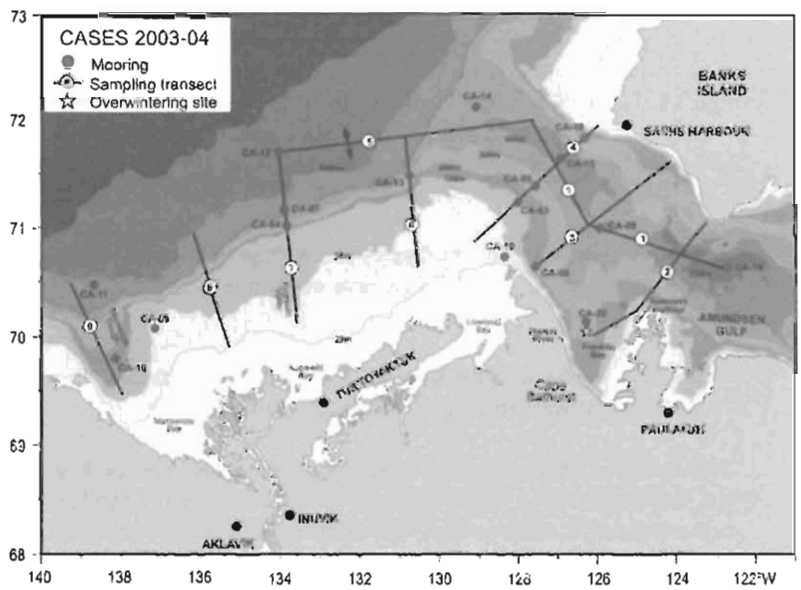

Figure 2. CASES study area indicating mooring locations, transect lines, overwintering location of the Amundsen and ISR communities participating in the study.

Summary of Methods and Preliminary Results

Having just completed the 2002 fall expedition and the full annual cycle field experiment in 2003/2004, the team is just now beginning to appreciate the wealth of scientific data which has accrued from this project. We don't have space to do justice to the full range of projects which have been carried out but rather provide a synopsis of the principal methods and analysis plans linked to each subproject as a means of illustrating the multi and interdisciplinary nature of this network:

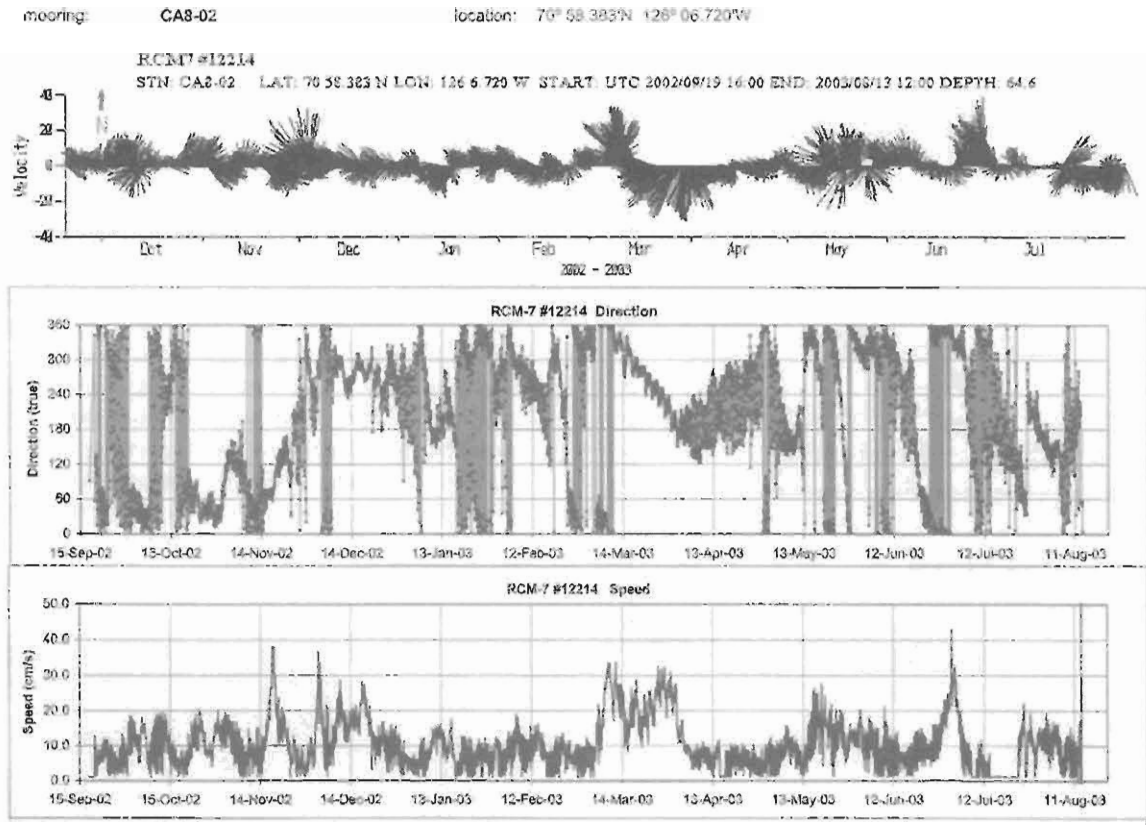

Figure 3: Time series of velocity (stick-plot of vector pointing in direction of current) in cm/s, direction current vector pointing (degrees True), and speed (cm/s) at station 8 in 2002-2003 at a depth of 65 m. Observations taken with Aanderaa RCM-7 current meter.

Atmospheric and Sea Ice Forcing of Coastal Circulation (Ingram and Carmack, PIs)

The focus of this subgroup is to understand the role of sea ice variability and atmospheric forcing on the physical oceanographic processes. We used long-term mooring of current meters and temperature-salinity recorders in the study area, and CTD (temperature-salinity profiles with depth) over a wide grid of stations on the Mackenzie Shelf to trace water masses and mixing. As a preliminary survey, our group deployed eight current meter moorings for one year of sampling on the Mackenzie Shelf and Amundsen Gulf area in fall 2002. A larger mooring program at 19 sites was undertaken in 2003-04, in addition to the over-wintering of the CCGS Amundsen. *In situ* meteorological observations were carried out both from the ship and from shore-based climate reporting stations. These included standard met observations from towers and a cloud macrophysics program. The ocean physics program is closely linked with research work on sea ice, meteorology, and on understanding physical-biological coupling in the marine ecosystem (subgroup 2).

Analysis of data from the instruments (current meters and T-S recorders) deployed over the 2002-2003 period has just been completed. To illustrate our observations, we show the sea water temperature recorded at a depth of 27 m at stn. 8, in the middle of Amundsen Gulf, which indicates a close relation with the presence/absence of sea ice in modulating temperature fluctuations (Figure 3). Further west on the shelf, significant upwelling events were recorded off both Mackenzie and Kugmallit Canyons. The presence of a sea ice cover seems to play an important role in strengthening the link between local wind forcing and the magnitude of cross shelf transport. At the mouth of the Amundsen Gulf, preliminary results show that (tidal) upwelling events have a major impact on the biological production and biomass distribution (Jean-Eric Tremblay). Shipboard profiling with the rosette (fluorescence, dissolved oxygen, nitrates and density) suggests that the physical and biological structures have a length scale of less than 20 km. Since the rosette stations are 10-12 km apart, in June-August 2004 we used an MVP (a free fall towed fish with the same sensors as the rosette, excepting nitrates) to obtain a ~1 km sampling resolution, so as to resolve the finer frontal structures.

Ice-Atmosphere Interactions and Biological Linkages (Barber, PI)

Field deployments for this subgroup varied according to whether the ship was mobile or fixed within the fast ice of

Franklin Bay. Teams from the University of Manitoba (Barber, Hanesiak, Papakyriakou), York University (Taylor), University of Calgary (Yackel), the University of Miami (Minnett), National Environmental Research Council, Denmark (Rysgaard), Dunstaffnage Marine Laboratory, Scotland (Wadhams), Canadian Ice Service (DeAbreu), Arctic Weather Centre (Hudson) and Fisheries and Oceans Canada (Prinsenberg) participated throughout the experiments. In the marginal ice zones we focused on sea ice formation processes, radiative exchange across young ice interfaces and microwave remote sensing of young ice. Gas flux measurements were made using a bow-mounted eddy correlation system coupled to a fast response CO_2 and water laser diode system. Surface meteorology included rawinsonde launches, hourly manned observations, upward-looking microwave radiometer, all-sky camera, and cloud ceilometer. Aircraft surveys were used to support regional scaling studies to couple the surface and atmosphere exchanges of mass, gas and energy. During the fast ice studies we installed and operated various surface meteorological stations including eddy covariance flux measurements from a 4.3m tower, radiation and visibility sensors, an acoustic Doppler sodar, an electric field meter and two 10m meteorological towers. Particle counters and high-speed cameras provided real time estimates of particle number densities during blowing snow events. The group also installed a variety of surface-looking electromagnetic sensing equipment including microwave scatterometers, radiometers and spectrometers. Physical sampling was done throughout the fast ice period for snow/sea ice geophysics, dielectrics, thermodynamics and processes controlling blowing snow, sea ice deformation, catchment area hydrology and permeability of the snow/sea ice system to gas, mass and energy. Subgroup 2 also collaborated on a dive program as part of the CASES spring 2004 experiment where measurements of under-ice microstructure, irradiance and brine migration studies were conducted with divers from the Freshwater Institute in Winnipeg.

Analysis of this subgroup's results will focus on a variety of process studies examining how the physical aspects of the ocean-sea ice-atmosphere system function. Some of these studies will focus exclusively on physical process studies (e.g., brine migration in the snow/ice system, blowing snow, boundary layer processes, synoptic and mesoscale meteorology/climatology, cloud macrophysics, etc.) while others will examine how aspects of the physical system control associated aspects of the biological system (e.g., catchment hydrology as a control on ringed seal and polar bear habitats; snow metamorphism as a control on PAR transmission through snow and sea ice, etc). Other studies will link to various remote sensing platforms to produce improved estimates of both the geophysical and thermodynamic state of the snow/sea ice system throughout an annual cycle. As an example of the types of data we provide an example of Eddy covariance heat flux and temperature profile data (Figure 4) indicates that heat fluxes in January and February were predominantly upwards, and associated with heat conduction through the ice and thin snow cover. Upward heat fluxes of up to 30 Wm^{-2} were observed, coupled with air temperature decreasing with height, typically by about 0.5°C/m in the lower boundary layer. Note that sea water temperature was generally constant near -1.5°C and the temperature at the ice – snow interface was typically 6°C warmer than the air. Snow depth during this period was variable but typically about 10 cm. The period on January 29 with strong downward heat flux and stable stratification occurred when air temperatures had risen steadily from -35°C to a maximum of -17°C over a 3-day period of "warm" southerly winds.

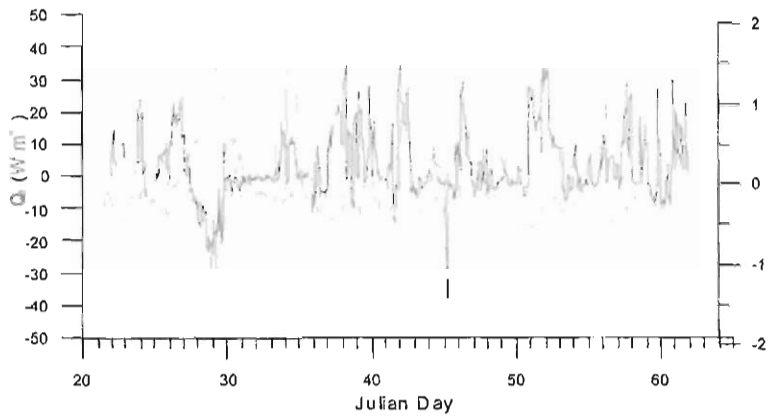

Figure 4. Heat flux data from eddy covariance and air temperature difference (9.5m – 0.5m).

Light, Nutrients, Primary and Export Production in Ice-Free Waters (Demers, PI)

Subgroup 3 focuses on understanding the dynamics of the development of planktonic and benthic algal communities in polar ecosystems and the role of these biological components in biogeochemical processes. Planktonic and benthic microalgae production estimates for the arctic continental shelves are scarce due to the difficulties associated with access to these areas. Furthermore, the mechanisms related to the inter-annual variability of primary production with regard to natural physical and/or biological forcing are not well known. Finally, the level of contribution of phytoplanktonic cells to the vertical biogenic carbon flux and the present and future role of the biological pump in the arctic waters in response to the variability of ice cover are not well understood. Therefore, the main objectives of our group are: 1) to determine the biomass and the production of pico-, nano- and microphytoplanktonic cells in the photic zone over the Mackenzie Shelf and in the Cape Bathurst polynya area; 2) to evaluate the relative contribution of phytoplankton and microphytobenthos to the total primary production in these same areas; 3) to assess the effects of the bio-optical factors on the vertical attenuation of the ultraviolet component of the solar spectrum in the water column; and 4) to define the bio-optic characteristics of the assemblages of pico- and nanophytoplanktonic cells by flow cytometry, to calibrate SeaWifs satellite images which reflect the local characteristics of the Beaufort Sea (P. Larouche, DFO).

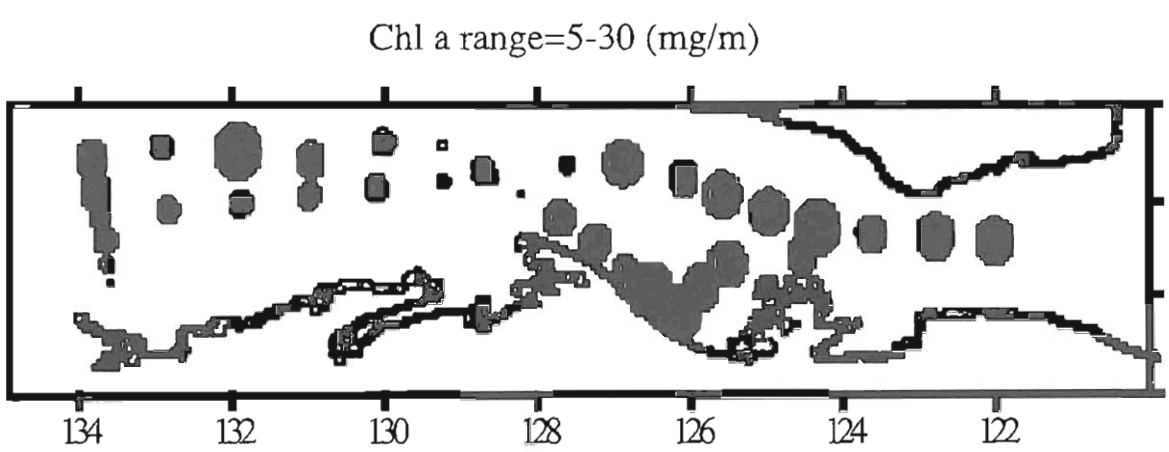

Figure 5. Total chlorophyll concentrations integrated over the total water column.

During fall 2002, total chl *a* concentrations varied between 0 and 1.6µg L^{-1}. Chl *a* maxima were found within the first 10m of the water column for 31 stations, within the 50-60m layer for stations 36, 42, 45, and 49 (more offshore stations) and close to the bottom for stations 62 and 65 (stations close to the Mackenzie River). In waters deeper than 78m, chl *a* concentrations were always less than 0.1µg L^{-1}. Except for more coastal stations, phytoplankton biomass was mostly attributed to cells smaller than 5µm. Chl *a* concentrations vertically integrated over the entire water column varied between 1.8 (station 33) and 31.8 (station 12) mg m^{-2} (Figure 5). In the present study, the Franklin Bay, the south-western Banks Island area, Amundsen Gulf, and station 42 were clearly identified as exhibiting the greatest phytoplankton biomass. POC concentrations varied between 82 and 1686 µgC L^{-1} with lowest concentrations found in the outer-shelf area, higher concentrations found in surface and bottom waters, and highest concentrations close to the Mackenzie Delta (data not shown). Chl *a* and POC values recorded during fall 2002 are similar to those reported by Iseki *et al.* (1987) who studied only the western section of our study area.

Microbial Communities and Heterotrophy (Vincent, PI)

Micro-organisms contribute a major fraction of the total biological carbon stocks in the CASES study region, and are also likely to play a leading role in biogeochemical fluxes. The microbial ecology subprogram was therefore formulated to measure microbial community structure and production dynamics, including comparative measurements in the inshore delta and Mackenzie River source waters. Initial sampling took place during the CASES 2002 cruise, and this led to sampling strategies for the subsequent full year program from CCGS Amundsen (CASES 2003/4), and modification of some methods (e.g., bacterial production protocols) to adjust to conditions found in this freshwater-influenced region of the Arctic Ocean. It also gave rise to the CASES satellite program ARDEX 2004 (Arctic River Delta Experiment) in which the shallow draft vessel CCGS Nahidik was used to make parallel measurements in the Mackenzie River and freshwater-saltwater transition zone.

We have now entered the phase of sample analysis and laboratory data production for this subprogram. Molecular genetic studies are being undertaken on DNA extracts from CASES samples by laboratories around the world specializing in different groups of marine microbiota including viruses (Curtis Suttle, UBC), picocyanobacteria (Annick Wilmotte, Université de Liège, Belgium), pico-eukaryotes (Connie Lovejoy, Université Laval and Carlos Pedrós-Alió, ICM, Spain) and bacterial heterotrophs. Pigment signatures of the microbial autotrophs are being analyzed by High Performance Liquid Chromatography at Université Laval and ISMER (Sylvia Bonilla and Suzanne Roy) and are showing a surprisingly large contribution by Chlorophyll b-containing microbes (Figure 6). Seasonal changes in microbial rate and state variables are now being analyzed, and the resultant data base should lead to a greatly improved level of understanding about the microbial structure and functioning of the coastal Arctic ecosystem. In addition, a variety of experiments have been undertaken by CASES PIs (including Jody Deming, University of Washington, working on sea ice microbial processes; Chris Osburn, Naval Research Laboratory, Washington DC, DOM photochemistry; Dolors Vaqué, ICM Spain, microzooplankton grazing; Warwick Vincent, Université Laval, bacterial heterotrophy and food webs) and their students, postdocs, technicians and collaborators, to provide new insights into the controls on Arctic microbiota and carbon fluxes.

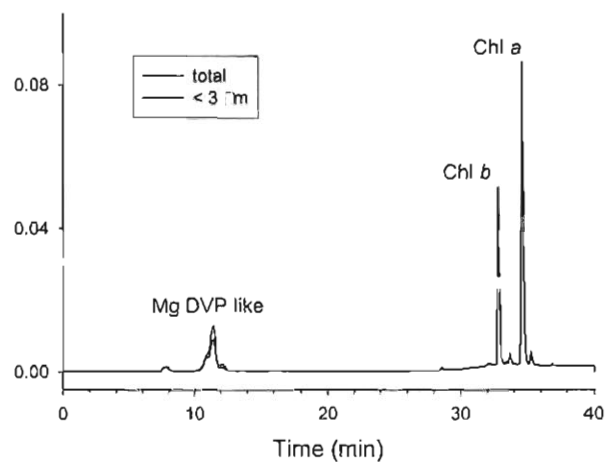

Figure. 6. HPLC fluorescence chromatograms for surface samples at station 65, CASES 2002 (S. Bonilla et al.).

An unexpected discovery from the CASES microbial program is the large (> 50%) contribution of extremely small Chl b-containing cells to the plankton in this coastal Arctic Ocean system. DNA analyses are showing a remarkable diversity of pigmented and non-pigmented pico-eukaryotes in this < 3 micrometer fraction (C. Lovejoy et al.), with implications for food webs and the potential impacts of climate change.

Pelagic Food Web: Structure, Function and Contaminants (Deibel, PI)

Investigative teams from Memorial University, Université Laval, Fisheries and Oceans Canada, the University of Hokkaido and the University of Tromsø participated in legs on one or both expeditions. The focus of our group was to determine spatial and seasonal variability in the species composition, abundance and biomass of mesozooplankton and larval, juvenile and adult fish and to determine the rates of flow of organic carbon and contaminants through the pelagic food web. These measurements were made in the overall context of determining the effect of Mackenzie River outflow on processes on the Beaufort Sea shelf. Zooplankton and fish were sampled using a combination of tools, including a Hydrobios multiple net system (vertical tows), a BIONESS multiple net system (oblique tows), rectangular midwater trawl, multi-frequency acoustics, an epibenthic sledge (for benthopelagic zooplankton) and two types of video plankton recorder. In addition, large volume water samples and air samples were taken for determination of organic contaminants. Samples were taken using all of these tools throughout the study area throughout the year, including intensively sampled transects across the river plume and the mouth of Amundsen Gulf, and a long, time-series station in Franklin Bay during overwintering of the ship. Samples of water and plankton were also taken close to shore and in the river using zodiac and helicopter platforms, and at through-ice stations away from the ship during winter. Experiments with live zooplankton and fish larvae were done onboard ship to determine feeding, metabolic, egg production and faecal pellet production rates. Samples of suspended particulate organic matter, zooplankton and fish were taken onboard ship and frozen for later analyses onshore for lipids, fatty acids, bulk and amino-acid specific stable isotopes, halogenated organic contaminants including PCBs, toxaphene, DDT and chlordane, as well as tissue levels of total and methyl mercury.

Sample and data analyses by members of this subgroup will focus on a wide variety of process studies examining how food web structure (i.e. species, abundance and biomass) and function (i.e. rate processes of metabolism, feeding and reproduction) affect the spatially and seasonally variable flows of organic carbon and contaminants through the plankton and fish of the Beaufort Sea shelf. Some of these studies will focus on the effect of variable physical forcing on plankton abundance (i.e. the video plankton recorder and net tow studies), while others will examine how seasonal variability in Mackenzie River outflow affects the feeding and reproduction rates of plankton and fish and the relative rates of flow and terrestrial and marine organic carbon and contaminants through the pelagic food web (i.e. lipid, fatty acid and stable isotope studies, coupled with contaminants information). Early results contain many exciting surprises. For example, video plankton records have revealed many cases of dense aggregations of copepods and pelagic tunicates on the thermocline and pycnocline and the epibenthic sledge has contained several taxa of large crustaceans that may be new species or at least new reports from the Arctic Ocean. The EK-60 echosounder has provided evidence of large aggregations of Arctic cod in the Franklin Bay area in late winter/early spring, forming a single layer of fish under 150 m (Fig. 7).

Organic and Inorganic Fluxes (Hill, PI)

Subgroup 6 will examine the horizontal and vertical fluxes of inorganic and organic carbon over the annual cycle, and aims to understand the principal features of the interactions between the various phases of the carbon cycle. These carbon phases include supply from terrestrial and atmospheric sources, flocculation, burial in sediment, resuspension, and offshore transport. Due to the importance of nearshore fluxes in this subproject, a major north-south transect covered by the ship is being extended into Kugmallit Bay and into the shallow mouth of the Mackenzie River by teams of land-based scientists.

Suspended particulate material (SPM) load has been collected throughout the year from the ship, and at several times from shore-based stations. The results from leg 1 show, as expected, a decrease from the shoreward to the seaward stations (Figure 8). Concentrations are particularly high at stations in Kugmallit Bay. This is in contrast to the SPM concentrations measured at that location during late winter through landfast ice, which were extremely low. SPM concentrations are also significantly different between stormy and quiet sea states, emphasizing the importance of resuspension in transport.

The uptake of carbon from the atmosphere, or release from the ocean, is controlled by the gradient of the carbon dioxide partial pressure (pCO_2) between the two reservoirs, as well as by climatological factors such as wind speed and ice cover, and by the nature of the air-sea boundary microlayer. In order to determine the characteristics of the CO_2 exchange at the air-sea interface, water samples were collected throughout the water column at nearly all stations visited by the ship between September 2003 and August 2004 (Lisa Miller and Al Mucci), and from land-based stations during August 2004 (Gwyn Lintern). Preliminary results show that the low salinity ($21 < S < 28$) but cold surface waters ($-1.52°C < t < -0.87°C$) sampled on the Mackenzie shelf are undersaturated ($235\ \mu atm < pCO_2 < 310\ \mu atm$) with respect to the overlying atmosphere and serve as a sink for atmospheric CO_2, at least during late September to early December, 2003.

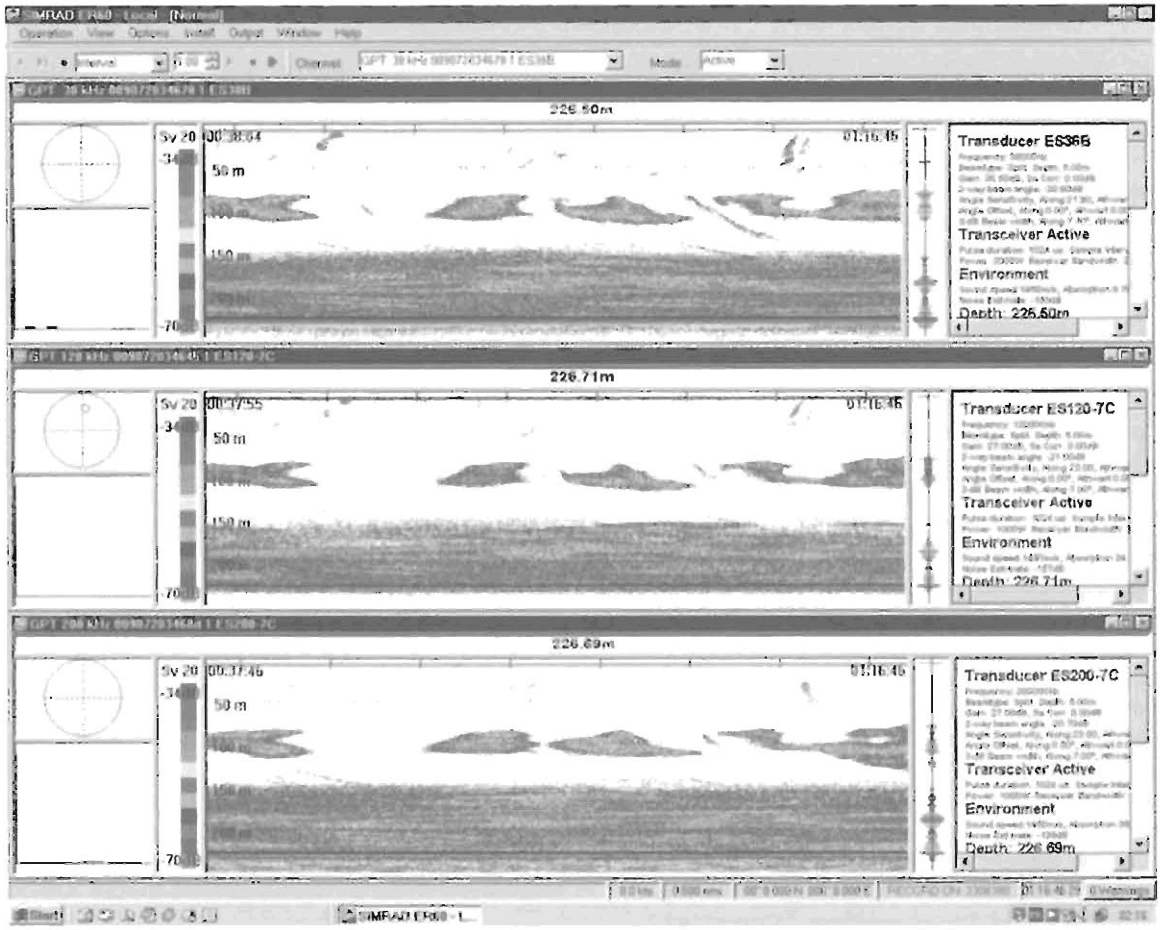

Figure 7. Multi-frequency acoustic image of layer of arctic cod (yellow) below 150m depth in Franklin Bay.

With the breakup of winter ice, we continued to compare nearshore to outer shelf processes. As well as continued sampling from the CCGS Admunsen (Lisa Miller, Al Mucci, Bjørn Sundby), a team of researchers from subgroup 6 has set up a field camp in Tuktoyaktuk for most of summer 2004 (Gwyn Lintern, Jon Grant, Tony Walker, Peter Cranford, Phil Hill). This nearshore work included profiling Kugmallit Bay using an undulating tow-fish equipped with DGPS, CTD, oxygen, turbidity, and chlorophyll sensors and zooplankton counts via an optical plankton counter. The benthos was surveyed using an echosounder bottom classification method. Sediment samples have been taken from the water column for characterisation of floc properties (video imaging) and chemical speciation. Cores are providing information about the geotechnical and biogeochemical properties of the sediment beds. Measurement of bed erosion thresholds have been undertaken, and will be used alongside wave and SPM measurements to model deposition and resuspension of flocs.

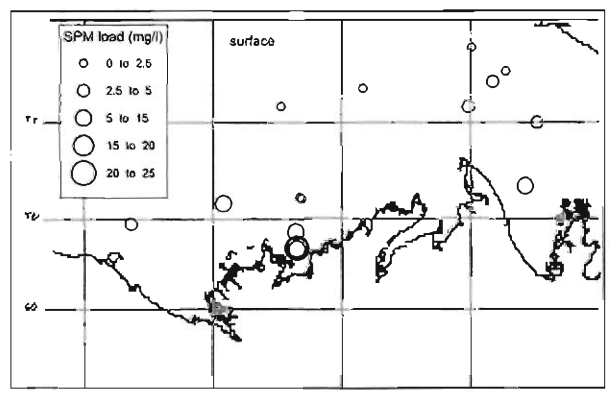

Figure 8. SPM load leg 1. Concentrations of suspended particulate material are significantly higher at nearshore stations, and also higher throughout the southern study area during stormy periods (not shown).

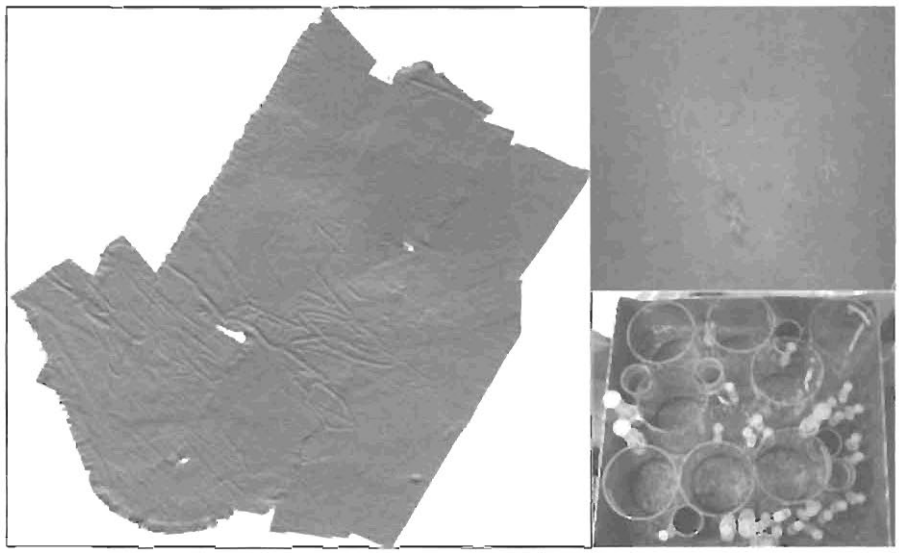

Figure 9. Multibeam sonar images of ice scouring on the seafloor portrays the limit of ice scouring in the vicinity of the 400-metre isobath within Amundsen Gulf. At greater depths (blue tones) ice scours are absent or have been infilled with sediment. Bottom photographs indicate an abundance of brittle stars in association with an isopod (at centre of the photograph), a soft coral (in middle foreground of the photograph) and bivalves (indicated by paired holes in the seafloor). Incubations of benthic fauna recovered in box cores assist in understanding carbon cycling processes over this important Arctic shelf.

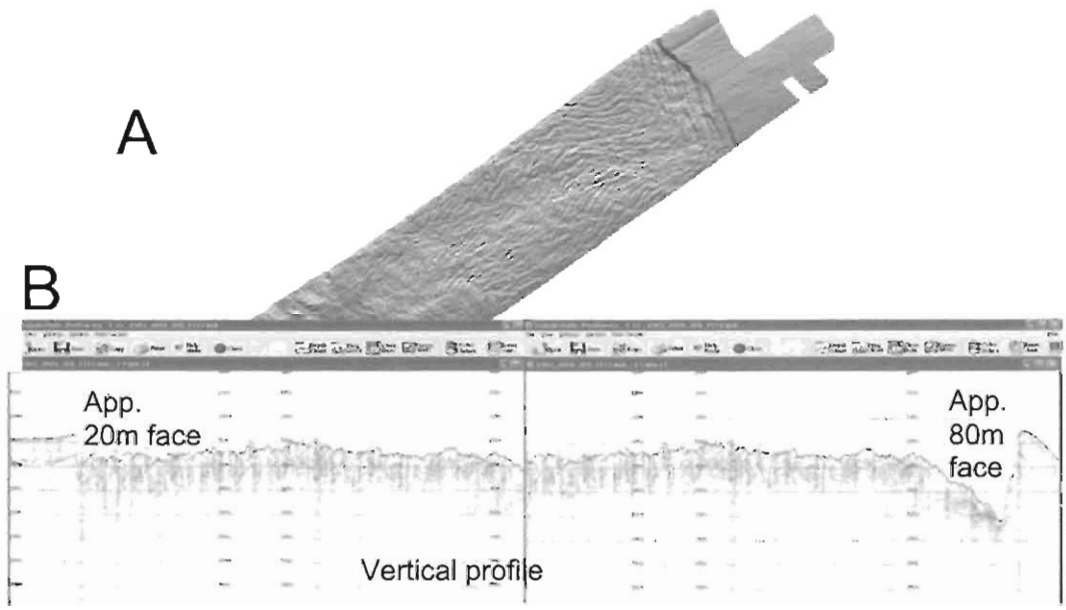

Figure 10 A - Multi-beam image of the slump feature. North is up so the foot of the slump is just to the east of the image in about 200m of water. The distance from one vertical wall to the other is 10-15km. We believe, based on the sharpness of the sides and slumps, that this feature is presently active. Figure 10 B - Vertical profile taken along with multi-beam which illustrates the sharp relief of the edge walls.

Benthic Processes and Carbon Cycling (Aitken, Conlan, Renaud PIs)

Subgroup 7 focuses on the ecology of marine organisms that inhabit ocean floor (benthic) habitats. Our research is focused on documenting changes in the species composition of benthic animal communities in response to seasonal variations in the quantity and quality of organic matter delivered to the seafloor, and spatial variations in the intensity of sea ice scouring of the seafloor. Changes in benthic community structure influence the pathways of trophic exchange (food-web structure) and the rate that food (measured as carbon) is processed in seafloor sediments. Thus the benthos is critical for determining the fate of carbon in the ecosystem. Our work onboard *CCGS Amundsen* involves the acquisition of various types of information about the seafloor; water depth, seafloor topography and sediment texture, the nature and quantity of organic matter stored within seafloor sediments, the distribution and abundance of benthic organisms, and rates of benthic respiration to determine rates of carbon mineralization at the seafloor.

CCGS Amundsen is equipped with two acoustic instruments, the Simrad EM300 and the Knudsen 320R. The Simrad EM300 is a multibeam sonar system that provides information for ocean bathymetry, the nature of seafloor sediments (based on acoustic reflectivity or backscattering), and the intensity of sea ice scouring (Figure 9). The Knudsen 320R is a low frequency sub-bottom profiler which provides high-resolution imagery of sediment thickness and internal structure up to 70 metres below the seafloor. The data acquired by these two systems can be combined to create a three-dimensional perspective of the seafloor and the underlying sediment structure. This information is essential in box coring and piston coring operations. A bottom camera was used to acquire images of the seafloor in an effort to estimate the densities of epibenthic organisms and to 'ground-truth' acoustic reflectivity data prior to coring. These images (Figure 9) are valuable in determining community structure, especially of those organisms that are either able to avoid the box corer or are at densities below which they are adequately sampled by box coring. A variety of invertebrate taxa were recorded in box core samples: polychaetous annelids, amphipod crustaceans and bivalve molluscs dominate the macrobenthos. Brittle stars, sea stars, and large isopods (Figure 9), may be important contributors to total community respiration, which would suggest a fundamentally different perspective on seafloor cycling in Arctic shelf environments.

Millennial-Decadal Variability in Sea Ice and Carbon Fluxes (Scott, PI)

The central premise of subgroup 8 is to provide calibration for the various climatic models to determine which one is the most reliable using the paleo-climatic record obtained using sediment coring techniques that enable us to capture the last 10,000 years of ice history on the Mackenzie shelf and slope as well as Amundsen Gulf. As this is written we have now collected 7 cores that cover water depths of 100-1200m, which covers the shelf and onto the slope under the present edge of the Arctic ice pack. It was very important to get cores under the present ice edge since that is where the major part of the ice edge change will be detected. We have a variety of proxies to determine ice extent-diatoms and dinoflagellates which are microscopic plants that wax and wane depending on ice cover, planktonic foraminifera who follow the plants and benthic foraminifera which will help to track bottom water exchange from the shelf to deep sea. These organisms all leave a fossil record and occur in large numbers (several 1000 per ml) which makes it possible for us to obtain a reliable record from small diameter cores otherwise not obtainable with large macro-invertebrates. This record will allow us to determine prehistoric records for conditions warmer or colder than those recorded in historical times. This problem in initialising (and validating) climate models is particularly severe in the Mackenzie Delta-Beaufort region where written climate records cover only the past century and oceanographic data cover only the past 30 years. Validation of carbon flux models also requires quantitative measurement of sediment sink values, e.g. changes in rates of carbon burial, amounts of terrigenous vs. marine carbon inputs.

The central objective of this CASES project arises from the premise that historical changes in Arctic sea ice and related ecosystem responses may reflect global warming and anthropogenic greenhouse effects. Proxy-data from marine sediments in the eastern Arctic and Chukchi seas, however, show that greater changes occurred in the past, including ice-free intervals and relocations of the Beaufort Gyre. Validation of regional models of ecosystem responses to Arctic ocean-atmosphere forcing thus requires geological proxy-data to define realistic initial values for "warmer-than-now" scenarios. The main objectives of this paleoclimate subgroup are to obtain decadal-millennial scale records of quantitative variations in Mackenzie River discharge, sea ice conditions, summer sea surface temperature (SST), salinity, primary productivity and carbon storage during the past 10,000 years. Changes in the Beaufort Gyre and shelf water circulation will also be determined from the provenance of ice rafted detritus, which documents the history of the Arctic Oscillation. We hypothesise that proxy-data from two cross-shelf transects of sediment cores will record SST oscillations of about 2-4°C, with concomitant reductions in sea ice extent and increased bioproduction. The extent of open water will also largely delimit the history of Cape Bathurst Polynya. The precision with which the rate of change and duration of these paleo-climatic oscillations can be measured will be affected by the depth of cryoturbation at different sites. Cores are therefore located using high resolution multibeam and seismic reflection profiles to obtain decadal-centennial records. Improved correlations between environments and algal production will refine paleo-salinity and - productivity estimates and the importance of shoreline thermokarst basins in carbon storage will be measured. The bottom surveys have provided some new discoveries in themselves. During one of these surveys we discovered a very large structure that appears to be some kind of retrogressive thaw structure. The structure, however, is several orders of magnitude larger than similar structures observed on land according to Alec Aitken. If this structure were to fail it could "exchange" several cubic kilometres of sediment from the shelf to the deep sea in the Mackenzie Trough. It is 15 km across and has slopes on the sides of up to 80m in height (Figure 10). We did not have sufficient time in Leg 8 to completely survey this structure but it is something that we intend to investigate further.

CASES modelling subgroup (Arrigo, Hanesiak, Holland PIs)

A modeling effort is underway through collaborations among the University of Manitoba (Hanesiak, Barber), New York University (Holland) and Stanford University (Arrigo). This coupled atmosphere/sea ice/ocean/ecosystem model will be used to address the central CASES hypothesis that the atmospheric, oceanic, and hydrologic forcing of sea ice variability dictates the nature and magnitude of biogeochemical C fluxes on and at the edge of the Mackenzie Shelf. Specifically, the model will be used as a

tool for synthesizing and interpreting the vast array of data that were collected during the course of the project and to test key scientific hypotheses. The modeling approach is to first construct a numerical model of atmosphere-ice-ocean system in the CASES region, with emphasis on first-year sea ice processes, and then to couple the physical model to a biological ocean/ecosystem model. We will validate both the physical and ecological models against observations taken during CASES. To date, each of the component models has undergone a separate development phase, and planning is underway for the coupling of the various components.

Atmospheric modeling currently underway includes model comparisons (polar vs. arctic MM5), case study validation using a plethora of in-situ meteorological/sea ice field data, and process studies focusing on low cloud, weather system evolution, and extreme events. The atmospheric model output will serve as forcing for the ice/ocean/ecosystem model. Initial state variables in the ecosystem model include multiple phytoplankton and zooplankton groups, nutrients (e.g. silicate, nitrate, and phosphate), detritus, the carbonate system, pCO_2, and air-sea exchange of CO_2. This suite will be refined, however, as new information from CASES becomes available. The approximate area to be modeled can be seen in the MODIS/Aqua satellite image from June 16, 2004 (Figure 11). This image also shows the diverse nature of the surface sea ice cover types (pack ice to the north, fast-ice along the shorelines and marginal ice zones).

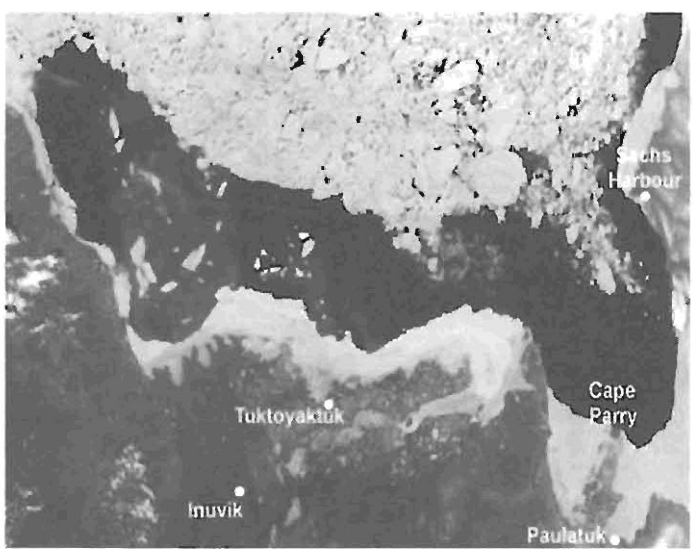

Figure 11: June 16, 2004 MODIS/Aqua satellite image of the CASES and surrounding regions (http://rapidfire.sci.gsfc.nasa.gov/)

Where to from here?

We believe the CASES program, to date, to be an unprecedented success. We have logged over 400 days at sea, over 500,000 person-hours of sampling, with several thousand kilometres of coordinated interdisciplinary science where multidisciplinary measurements are combined in space and time. The unique ability to measure physical processes from the bottom of the ocean to the top of the atmosphere, coupled with a complete ecosystem study from viruses to whales provides the 'systems' level detail required to understand processes of change in this region. Through CASES we have begun to see changes in the Beaufort Sea that are significant in the physical, biological and geopolitical sense. Sea ice areal extent and thickness have shown a dramatic reduction over the past several decades, with particularly significant reductions in the CASES study region (Barber and Hanesiak, 2004). These changes in the western Arctic are accompanied by observed changes in sea ice concentration at the hemispheric scale of about $30 \pm 3 \times 10^3$ km^2 per year over the period 1973 to 2002 (Cavalieri et al. 2003). This implies that processes coupling sea ice, water mass properties and biogeochemical fluxes are in a state of change. Computations using a 70 percent sea ice concentration (SIC) minimum show that we have lost about 29 percent of the minimum extent of sea ice over the period 1979 to 2002 (Figure 12). If we project this trend into the future (granted a questionable practice) we can expect to have a seasonally ice free Arctic Ocean as early as 2050/2060.

ArcticNet

The variability in physical-biological coupling we are currently studying in the CASES research network are panarctic in nature as evidenced by the hemispheric reductions in sea ice concentration (SIC) anomalies (Figure 12). Research is desperately needed within all of these regions to inform policy and to prepare for mitigation and adaptation to arctic climate change. For Canadian continental waters we intend to do this through a recently funded Network of Centres of Excellence (NCE) known as ArcticNet (http://www.arcticnet.ulaval.ca/index_en.asp). ArcticNet will build synergy among existing Arctic Centres of Excellence in the natural, medical and social sciences, to become the "research arm" of existing networks of decision- and policy-makers for the Canadian Arctic. The central objective of the Network is to translate our growing understanding of the changing Arctic into impact assessments, national policies and adaptation strategies. The direct involvement of Northerners in the scientific process is a primary goal of the Network that will be fulfilled through bilateral exchange of knowledge, training and technology.

Over the next seven years and beyond, ArcticNet will considerably widen and update the observational basis in the Canadian coastal Arctic by conducting highly integrated, multidisciplinary studies in three key arctic regions: the East-West gradient in the marine coastal Canadian High Arctic (Theme 1, L. Fortier PI); the North-South gradient of coastal terrestrial ecosystems in the eastern Arctic (Theme 2, W. Vincent PI); and the land-ocean interaction zone in Hudson Bay (Theme 3, D. Barber PI). Each of these Integrated Regional Impact Studies (IRIS) will contribute the knowledge needed to formulate policies and adaptation strategies for the Canadian coastal Arctic (Theme 4, G. McBean, PI). We encourage new and evolving partnerships from within the ranks of CMOS and other national and international science organizations as we seek the knowledge required to adapt to changes occurring within our Canadian Arctic coastal environments.

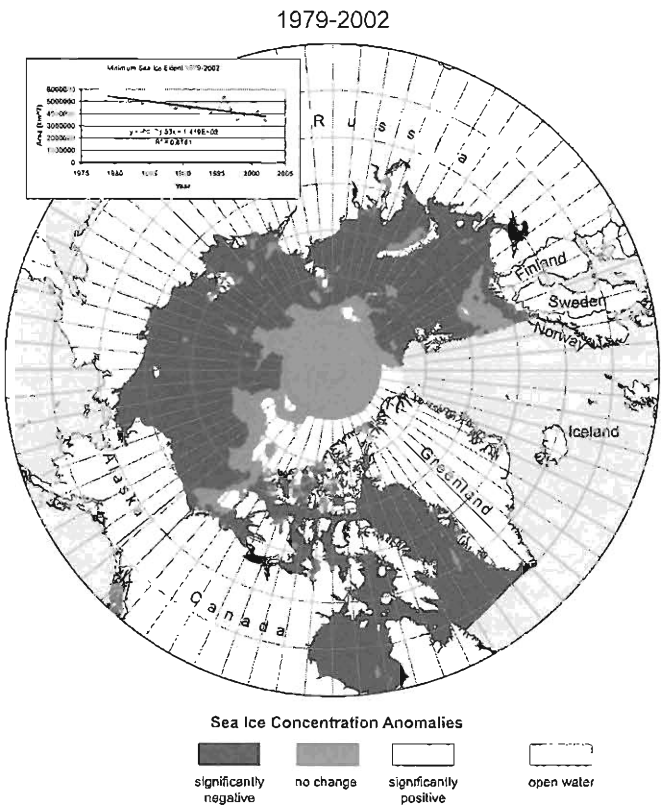

Figure 12. Trend in weekly sea ice concentration anomalies over the period 1979 to 2002. Blue indicates geographic regions with negative sea ice concentration trends (loss of ice) and red indicates positive trends (increased concentrations). Graphic inset shows the hemispheric average trend in concentration for regions with _70 percent sea ice concentration at the end of the summer melt season (Barber, unpublished).

Acknowledgements

Thanks to the officers and crew of the CCGS Amundsen, Pierre Radisson, Laurier and the Nahidik for excellence in field support. CASES is supported through an NSERC network grant, various Canada Research Chair awards and individual NSERC discovery grants. Support is also provided by Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada, and the Polar Continental Shelf Project. Thanks to each of the CASES subgroups for contributions to this article.

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Prochain numéro du *CMOS Bulletin SCMO*

Le prochain numéro du *CMOS Bulletin SCMO* paraîtra en **décembre 2004**. Prière de nous faire parvenir au plus tôt vos articles, notes, rapports d'atelier ou nouvelles à l'adresse indiquée à la page ii. Nous avons un besoin **URGENT** d'articles.

Next Issue *CMOS Bulletin SCMO*

Next issue of the *CMOS Bulletin SCMO* will be published in **December 2004.** Please send your articles, notes, workshop reports or news items at the earliest to the address given on page ii. We have an **URGEN**T need for your articles.

AQ2004 – Third Canadian Workshop on Air Quality
Québec City, QC, Canada, March 24-26, 2004

by Richard Ménard[1], Véronique Bouchet, Louis-Philippe Crevier, Alain Robichaud and Brian Wiens

Introduction

The Meteorological Service of Canada organized the third Canadian workshop on air quality in Quebec City, from March 24 to 26, 2004. Nearly 100 participants with seven invited speakers discussed the science, policy and economic aspects of air quality with this year's focus on "Pollutants across boundaries: The atmospheric transport of pollutants in North America". Canadian and international participants from the USA and Mexico attended this event. The workshop had a total of nine sessions discussing modelling, science and policies, monitoring and analysis, issues on society, and programs in regions. The workshop ended with a session on discussions with recommendations.

A – Opening Session

The opening session had an international flavour. Invited speakers from USA, Mexico, and Canada introduced their air quality forecast programs and discussed the impact of air quality on heath and the economy. The session chair, S. Venkatesh (MSC), made the remark that at the international level there are no policies as such but rather agreements and protocols. Phil Blagden of the Policy and Corporate Affairs Directorate of MSC gave an overview of the Canadian air quality forecast program. The goals of the program are: 1 – to provide information to susceptible individuals with daily air quality health risk; 2 – to support reduction of pollutant emissions by individuals, organizations and communities; and 3 – to support the public's "right to know" aspect on air quality. As noted by Blagden, meeting those objectives has some implications: 1 – that the forecast program must respond to health science; 2 – that there is internal and external partnership; and 3 – that information must be accessible and transparent. The national air quality forecast program became operational in 2001 and using CHRONOS (Canadian Hemispheric and Regional Ozone and NOx System) as the main chemical transport model, with forecast mainly limited to the summer period. Today, most regions in Canada are or are moving towards providing year-round air quality forecasts, and that the path forward will make use of more data assimilation capabilities, that additional pollutants, in addition to ozone, will be included in the forecast, that there will be forest fire episode smoke forecast, and further improvement of services and presentation, building national outreach.

Dr P. Davidson, a manager at NOAA, then presented the USA's National Air Quality Forecast Capability. An agreement between NOAA and EPA was signed sixteen months ago to develop an end-to-end nation-wide air quality forecast program. The initial phase, which will be completed in September 2004, will focus on providing one-day guidance of ozone over the Northeastern part of the USA, and will extend the domain to the whole country in five years. In 2008, the forecast capability should include PM2.5 and in ten years from now extend the forecast range to 48-72 hours and include more pollutants. In the initial phase, the off-line model Community Multi-scale Air Quality model (CMAQ) driven by the NCEP mesoscale model Eta-12 will be used for the prediction which will be delivered by the National Weather Service through the telecommunications gateway and from EPA sites for users to pull. In a test case conducted over the summer 2003, systematic errors were identified and corrected. These are: a general over-prediction of ozone, errors in elevated areas and also at night. Several errors pointed to improving the linkage between the chemical transport model and the meteorological model, such as the planetary boundary layer, land-use and temperature interpolation error. More information on the program can be found at http://www.nws.noaa.gov/ost/air_quality/index.htm.

The third presentation of this session was made by Dr L. Drouin (MD) who presented the current knowledge of impact of air pollution on public health. This work was based on a study that was presented in a symposium held in Montréal two years ago, and which involved the collaboration among all four Universities in Montréal. The study indicates that black smoke has a strong correlation with exposure effects, contrary to ozone that shows not much correlation. This causes excess mortality due to cardiovascular problems. Also it was found that diesel fuel causes cancer. Wood combustion which is the third source of particulate matter (accounts for 35% of the PM2.5) creates formaldehyde, which can cause asthma and bronchitis. A study in California showed that the lung function growth in young children is diminished as a result of being exposed to pollution. In the study over Montréal it was noted that hospitalization was linked to the social-economic status, but also due to the downwind effect of the refineries (petroleum industry). It was also noted that allergic rhinitis affects about 10% of the population. With climate change, there is expected to be an increase in forest fires, causing an augmentation of VOCs and thus creating more ozone. Also, vehicular traffic has a large

[1] Air Quality Research Branch, Meteorological Service of Canada, Dorval, Qc.

impact on health. During the Atlanta Olympics (1996), there was a 42% reduction in hospitalization, attributed to reduction of traffic.

Dr L.R. Bracho from Mexico presented the regional impact of a power plant along the Gulf of Mexico, including an analysis of the regional health and economic impact due to pollution from the power plant. It was found that although ambient concentration may not exceed AQ standards at state level, it may still have a health impact on the local communities. The cost of the potential effect on health of communities exposed to emissions from the power plant was estimated at 33.6 Million dollars per year. Dr Bracho also presented another study giving a cost analysis of local pollution for Mexico City. It was found that the reduction of emissions that would result from using alternative technologies, such as hybrid buses, renovating the taxi fleet, co-generation, etc ... would result in a benefit of 200 M$ in reducing health costs against a cost of 50 M$ to perform these technological changes.

B – Modelling I

Several critical issues were discussed by speakers in this session and they could be summarized as follows: 1 – for any model, the most sensitive part is emission inventory and production of adequate emissions files (anthropogenic or biogenic); 2 – optimization of the code for massively parallel computers; 3 – compatibility of the model system with data assimilation systems; 4 – mass conservation of advection scheme (e.g. semi-lagrangian); 5 – resolution of AQ models which are too coarse to address local scales; and 6 – boundary layer formulations of AQ models are not capturing the diurnal cycle.

Description and verification of two models were presented in this session: CHRONOS (Canadian Hemispheric and Regional Ozone and NOx System) and AURAMS (A Unified Regional Air-quality Modelling System). J. Pudykiewicz presented the current status and future developments of CHRONOS. This model has been the operational AQ forecast model (real-time) since May 2001 for atmospheric trace constituents in Canada. It is also used to produce an off-line Objective analysis (real-time) since July 2003 over North America for surface ozone. Other current applications of the model are emission control scenarios and comparison to other AQ systems [such as AURAMS, GEM-AQ (an online air quality model using the MSC's operational meteorological model), CMAQ]. Future developments of CHRONOS include new parameterizations, high order semi-implicit Runge-Kutta method for the numerics and elimination of the operator splitting and development of high order Finite Volume methods for reactive flows on structured and unstructured meshes (in order to avoid problems of spherical geometry). A potential problem with these new methods is their incompatibility with existing assimilation systems which should be completely redesigned to take into account model grid changes. Finally, an adjoint and TLM (tangent linear model) of the model are being produced.

Verification of CHRONOS during summer 2003 (presented by R. Moffet) was done. For surface ozone, overprediction in the Northeastern part of North America in the afternoon and overdepletion overnight are noted. However, the correlation between observed and modeled values is relatively good for ozone but poor for PM2.5.

The AURAMS model (presented by M. Moran) is an episodic, eulerian, multi-pollutant, regional air-quality modelling system. It considers size-resolved and chemically-characterized aerosols (12 size bins from 0.01 to 40.96 μm) and aerosol composition with 8 chemical components (sulphate, nitrate, ammonium, sea salt, organic carbon, elemental carbon, crustal material and aerosol-bound water). AURAMS is considered as a tool to study the formation of ozone, particulate matter (PM) and acid deposition in a single "unified" framework and intended for research and policy issues. As for CHRONOS, the model is driven by GEM (Global Environmental Model) and emission fields prepared by the Canadian Emissions Processing System (CEPS). Recent additions in AURAMS include: vectorized heterogeneous-chemistry module (HETV), fetch modulation of sea-salt emissions in coastal areas, ice and mixed-phase cloud processes and emissions of wind-blown dust. One major drawback of AURAMS is the large amount of computer resources needed to run the model which is roughly one order of magnitude higher than that for existing models (CHRONOS, GEM-AQ), (note that this may change with the parallel computing environment).

Verification of AURAMS during the intensive measurement campaign PACIFIC 2001 Air Quality Study (Lower Fraser Valley, August 25-31, 2001) were presented by Paul Makar. It was shown that several important local-scale features of air quality were captured by model simulations. The model's ability to simulate both the broad features and the details of particle formation were emphasized. Finally, a setup to run AURAMS in real-time over North East America to forecast ground level ozone and PM was presented by Sylvain Ménard. Comparison of model output with observations from US-EPA AirNow database generally shows satisfactory results. Simulation of Hurricane Isabel on September 18th 2003 shows the importance of sea salt emissions to the total PM concentration.

C – Science and Policies

The session began with an invited talk by Dr S.T. Rao of NOAA who presented a critical discussion on the use of observations and model output for air quality management. First, it was pointed out that AQ models cannot be validated but are rather only evaluated against observations. Also, the evaluation of model sensitivity to emissions changes is needed to determine if model is a credible tool for emissions reductions scenarios. When the emissions reductions have an impact, it might be interesting to go back and have a look at previous projections and see if they occurred as predicted. What is missing in the US AQ model is long term scientific assessment such as over a year. There is also a need to find out more about model uncertainties and sensitivities. Uncertainties due to deposition, emissions and

chemical mechanism can be as much as a factor of two (e.g. CB4 vs SAPRC). Observation system is also a critical piece of the puzzle. Uncertainties in observations arise, for instance, from different networks because of different protocols. It is also important to have profile information for the evaluation of models in 3D. There is also a need for better appreciation of representativeness in observations and model outputs.

Ann McMillan then presented a critical review on how to get science for policy-making. First a review of some of the existing committees/organizations was given. The International Joint Commission (IJC), www.ijc.org/en/home/main_accueil.htm, for instance, was established in 1966 to advise governments focused on the border regions. The Canada-US Air Quality Agreement, and in particular the Annex 2 on ozone, gives a basis for scientific cooperation. The NAFTA – commission on environment (NAAWG) www.cec.org/pubs_docs/documents/index.cfm?varlan=english ... is yet another agreement that has a different objective. In general it is found that different policy groups are based on different contexts and sought for different science objectives. A few considerations are desirable when considering to go transboundary border shopping: 1 – Greater harmonization of monitoring and data analysis methodologies across the border; 2 – More consistent reporting across the border region – maps without borders – helps to highlight the underlying issues; and 3 – Consistent approaches to developing forecasts and indicators in the border region will aid future policy shopping.

Then there were two talks on future emissions scenarios which have both scientific and political implications. N. Pentcheva presented a comparison of emission reduction scenarios simulated by AURAMS and CHRONOS, using a future scenario of road vehicle emissions for the years 1995-2020. The comparison was made using the same resolution for both models. P. Miller talked about modelling of mercury deposition using future scenarios of coal combustion in the electric sector. The evaluation of the overall changes in the receptor lakes was the objective of the work.

Y. Bourassa and C. Labossière of Environment Canada presented some economic aspects of clean air initiatives. Y. Bourassa discussed the use of AQVMs (Air Quality Valuation Model). These are empirical studies on the economic value of environmental benefits and human health effects. They have been developed as a tool to help policy analysts assess the value of the benefits. A repository of such models can be found at www.evri.ca which is free access for Canadians. The repository is, however, incomplete and more effort and collaboration with atmospheric scientists are needed for the development of such a model database. C. Labossière presented the plan to develop the economic evaluation of the Canadian Wide Standard that should be implemented in 2010 review. The plan is to develop economic evaluations that go very deep into both micro- and macro-economic analysis, and which will require significant consultation with industry on the data needed for this process.

Intercontinental transport and related links with climate change were discussed last in this session. F.Conway explained the basic mechanism by which pollutants could be carried over between continents, and pointed out an interesting web page www.physchem.uni-wuppertal.de/PC_WWW_site/Bad_Breisig/breisig_WS1.html. He also pointed out that for policy we need to be able to distinguish and quantify local vs. hemispheric contributions, and that global/hemispheric chemical modelling is needed for such determinations. He also mentioned that in his view climate change policies should not be designed to adversely affect air quality. Dr Stone then followed up in giving a summary of the link between air quality and climate change. At the intersection of air quality and climate change there is tropospheric ozone and aerosols. Actually ozone is a more potent greenhouse gas than carbon dioxide. In addition, tropospheric ozone has doubled in the last century. Aerosols are short lived, as they can be washed out. Most aerosols will mask climate change (i.e. negative forcing), but black carbon creates a positive forcing. Climate change also impacts air quality. The increase in temperature is likely to increase extensive areas of stationary air masses leading to high production of tropospheric ozone. Also NO_x emission from soils is expected to increase due to temperature increase, but the increase of water vapour will decrease the amount of ozone. Also the increase of CO emissions due to forest fires and biomass burning changes the amount of OH which largely controls the oxidation capacity of the atmosphere. These and many other mechanisms contribute to the interplay of air quality and climate change.

D – Modelling II

This session began with two talks on GEM-AQ, an online air quality model coupled with the operational meteorological model GEM. Dr Lupu from York University gave a short introduction of the features of GEM-AQ. In particular it contains the Canadian Aerosols Module (CAM) which is a 12-bin size-resolving aerosol model. The aerosol forecast capacity was tested against the Québec forest fires of the summer 2002. Emissions were produced by the Fire Locating and Modelling of Burning Emissions (FLAMBE) System. The results showed that the envelope of the simulated smoke plume is correctly predicted, but the aerosol optical depth does not match the AERONET observations. The limitation is thought to be due to the background emissions that were not included in the simulation. Then Dr S. Gong discussed to what extent natural sources of aerosols, including forest fires, soil dust, sea salt and DMS contribute to PM2.5 and PM 10 in Canada using the Canadian Aerosol Module (CAM) that is used both in NARCAM and GEM-AQ. Results were shown for 1998 from biomass burning only and for spring of 2001 with all sources. The analysis is conducted by comparing the ratio of organic carbon or sea salt over the total mass of PM. In one of the two study periods, it was shown than

more than 80% of PM is due to organic carbon. Limitations of the study are due in part to the lack of biological species such as pollen and spores that are not included in the modelling system.

DiCenzo presented the result of two studies. The first one was an application of CMAQ over the pacific northwest to determine the importance of transboundary flow. CMAQ was setup over a domain that straddled 525 km each side of the British Columbia-Washington border. This length is suggested by North American accord to be the length needed to clearly attribute what is due to transboundary flow. Three nesting domains were used in order to account for complex terrain and land-sea breezes. Scenarios runs were made by turning off the US and Canadian anthropogenic emissions one at a time. Results can be obtained through ftp: juliet.pyr.ec.gc.ca, User: colin, Password: colin, then cd PWIAQMP. The second study, an ensemble air quality forecast approach, was used to assess the uncertainties in AQ forecasting. A multi-realization/multi-model approach was used using CMAQ and MC2 with different input meteorological fields. The system was assembled by RWDI and ran on an 80 node Linux cluster in less than 11/2 hours for 50 hours of simulation.

There were then two talks on chemical data assimilation. R. Ménard started first by illustrating the basic ideas of data assimilation using optimum interpolation using the ground level ozone observation network. By computing observation-minus-model residuals and taking spatial correlation statistics of these residuals it is possible to distinguish observation error variance from model error variance and estimate its spatial correlation, which is the information needed to construct a data assimilation scheme. The talk then considered the larger perspective of chemical data assimilation using GEM-AQ and satellite observations, and plans for the future. This was followed by a talk by A. Robichaud who presented details of the assimilation of ground-level ozone using CHRONOS. Results from the objective analysis were contrasted with those of the assimilation. In particular it was shown that a significant bias reduction can be achieved in assimilation mode, although the predictability skill or the impact of data is limited to 6 hours. Application of ozone assimilation to compute SUM60 and AOT40 were presented.

Three talks on emissions concluded the modelling session. The Canadian National Pollutant Release Inventory (NPRI) was presented by M Deslauriers. The inventory will be updated yearly. Reporting of emissions is now mandatory, including the oil and gas industry, and is made on a yearly basis. The information is also publicly accessible. Online queries and interactive mapping can be made at www.ec.gc.ca/pdb/nrpi/nrpi_online_data_e.cfm. Emission inventory 2000 will be available in April 2004. They also have a reanalysis of 1995 inventory. The NPRI web site also has emissions projections to future years and the Canadian version of Mobile 6. PM 2.5, PM10, and toxics are also part of the inventory collected by NPRI. L.-P. Crevier then talked about the ongoing activities at CMC on emissions modelling. In particular plans are to fully support SMOKE processing system in the future as the main emission modelling system for AQ applications. The session ended with a talk by R. Martin on the use of satellite observations in improving emissions. The method presented is not based on (?) inversion techniques for long-lived species, rather it focuses on short-lived species such as formaldehyde and NO_2 that can be measured by satellites. With short-lived species, horizontal transport has a negligible effect. It is possible then to map column concentrations with emissions using an air quality model. Building up a relationship between emissions and total column measurement, the satellite measurement can directly infer the emission to a known accuracy. R. Martin showed how this information can be combined with emission inventories to yield an improved emission estimate.

E – Monitoring and Analysis

The monitoring and analysis session was opened by James Drummond from the University of Toronto with a discussion of the capabilities and limitations of space-based observations of pollution. One of the key points was to be aware of what is being sampled both in terms of the physical portion of the atmosphere as well as confounding influence from other constituents. There is a substantial challenge in comparing point observations taken with traditional sampling equipment with the volume averaged results of a satellite measurement, frequently with interference from clouds, scattered radiation and usually not coincident in time. Several examples gave reasonable promise that usable information could be extracted from the data. Dr. Drummond concluded with the emphasis that satellite data must be put in the context of other measurements despite the challenges to do so.

Several talks on conventional observational methods followed starting with a summary of the CORE program by Maris Lusis. The CORE program has the objectives of providing a core set of long term observations to establish trends in atmospheric constituents and to set standards of practice for measurements. Measurements like the CORE program are vital in a society with a growing population and attendant growth in the consumption of fossil fuels, and other impacts such as the deforestation of the past century. The current strategy of the CORE network is to improve infrastructure to facilitate long-term monitoring, to encourage researchers to use CORE sites and data and to increase the scope of monitoring as resources allow.

Dennis Herod made a presentation on PM and ozone in the context of the planned Canada Wide Standards (CWS). The goal of CWS is to minimize the health impact of ozone and fine particles. Within CWS are provisions for the standards of ambient air, achievement reporting, trans-boundary issues and continuous improvement. Trans-boundary issues present one avenue of exemption where attainment could be beyond the control of the local jurisdiction. Overall the CWS provides specific targets for 2010 for areas that are currently exceeding the standard as well as incremental

improvements to areas that are within the guideline.

Hong Lin followed this presentation with a summary of ozone measurements including approximately 250 Canadian stations with the context of about the same number from the United States. Some of the stations have over 25 years of measurements. Using 80 parts per billion as a threshold for a high ozone day, these data show that the highest frequency occurs during June to August with the lowest in December to January. There was a great deal of interannual variation as well as strong regional differences. Southern Ontario, for example, is more prone to high ozone days than central Alberta.

David Waugh presented an analysis of trajectories reaching St Andrews, New-Brunswick and Kejimkujik park in Nova Scotia in the context of measured values of ozone, PM2.5 and gaseous mercury. For elevated PM2.5 and ozone there were strong correlations with trajectories that crossed through the United States. In the context of the CWS the highest PM2.5 and ozone events tended to occur with a Southwest flow. The relationship with mercury was not as clear although there were indications of a strong influence from chloralkaly plants.

Richard Leduc presented an analysis of trajectories into Southern Québec focusing on ozone observations. This analysis also considered meteorological character of the air mass by including the wet bulb potential temperature (thetaW). This demonstrated results similar to those in the Maritimes with the highest ozone generally occurring when there was a flow from the southwest over areas of the US or Southern Ontario, both with high emissions of precursors. These generally coincided with high thetaW. Interestingly they also observed events with low thetaW's from a northerly flow with elevated ozone levels that are probably indicative of substantial subsidence bringing ozone downward in the atmosphere.

Brian Wiens presented a summary of trajectories over the Prairies both in forward and backward modes. It was found that in the Prairies roughly 80% of 48 hour trajectories either originate or terminate within Canada. For specific stations such as Boundary Dam this is different but the overall picture is that international transport is less significant in Alberta, Saskatchewan and Manitoba than many other parts of the country. This analysis of flow will be used as the foundation for further work to stratify flows using observations of ozone and PM.

The session closed with a presentation on the impact of trans-boundary flows in Ontario on elevated smog levels, delivered by Neville Reid. One of the interesting factors was the impact of water on the apparent transport of smog and precursors. The greatest number of exceedances occurred over south-western Ontario near the lakes. This is also generally closest to upwind sources with limited local NOx sources that could titrate out ozone. The analysis over southern Ontario showed that in general high PM2.5 was preceded and accompanied by high ozone. The inclusion of PM2.5 in the calculation of the air quality index increases the number of days when degraded air is indicated. The PM2.5 also shows up occasionally in the wintertime when there is little ozone. The complexity of the issues of transport and formation emphasize the importance of multi-disciplinary approaches that include observations and modelling to understand the issues.

F – Society

Health issues and outreach were discussed in this session. Dr J. Sarnat of the Harvard School of Public Health discussed the issue of exposure, and in particular how ambient measurement can be related to personal exposure for a given pollutant. This information is important in order to establish a clear relationship between ambient measurement and adverse health effects. The results of a study involving over 4000 person-days of exposure data, where people actually carry multi-pollutant sampler for nearly two weeks were presented. These measurements are compared with ambient monitor measurements. In earlier studies done with single pollutants (Sexton et al. 1984) it was shown that there is no correlation between personal exposure and ambient monitor measurement. In this study a multi pollutants measurement showed that ambient ozone is a good surrogate for PM personal exposure. Also some other studies have shown that PM2.5 and sulfate have the highest mean correlation between personal exposure and ambient concentration, but for gases there is very little correlation with gases such as ozone. That may be due to the fact the SO_2 is low, and/or that ozone is reactive indoor. Ventilation is a key factor that relates personal exposure to ambient concentration. Also distance from roads is very important especially with black smoke (Hoek et al. 2001).

P. Blagden then presented an update on the progress made in defining an air quality index that would be based on health risk. Historically ozone was used to develop an air quality index, because of the monitoring network. But now we are changing to include PM2.5 with a 3-hour average (Americans are using 24-hour averages). The new air quality index that is being developed will be based on epidemiology studies (rather than just informative). One difficulty is that different values and criteria are used in different jurisdictions. Coming up with a formula is also challenging. But it is found that ozone and PM2.5 (perhaps we should also consider PM10) are contributing significantly, CO is not contributing, SO_2 can contribute in some places, and NO_2 is always contributing. The effort of defining a health risk AQI has started a few years ago and the goal is to have it peer reviewed and begin its implementation in Spring 2006.

In terms of outreach, F. Portalupi presented the Clean Air Online (CAOL): an integrated and multi-tiered web site for facilitating clean air outreach and information coordination. The goal is to have a web site. As you know EC is behind a firewall, so this is causing a challenge. The strategy is to have a duplicate site, one behind the firewall and the other publicly available. The launch date is June 21, 2004.

Behind the firewall www.gta.caol.ca and open to the public www.ec.gc.ca/caol. R. Dunkley then presented TRADE: The Transboundary Air Data Exchange. TRADE is a simplified graphical information system (GIS) that was used to display and share information in the Puget-Sound airshed. This project was funded by the Border Initiative. NAPS and AIRS database are used along with the software Statistica. Queries are made using a Microsoft SQL server, and make use of XHTML to display information.

G – Regional Programs

The main "raison d'être" of the Air Quality Prediction Program (AQPP) is to protect the public by providing advice to help reduce health risk on susceptible people. Generally speaking, regions have responded well to this mandate. Politically and legally speaking, CWS and the AQ US-Canada agreement are the main drivers of this program. The AQPP traditionally runs during the warm season (usually May 1st – Sept 30th) and covers the Southern portions of different provinces and territories. Recently, a winter air dispersion program has also been delivered as an official product and has become more and more popular among regions.

Regional AQ forecast program is a joint effort of Environment Canada, who usually supplies weather information, produces and disseminates the forecast together with local governments who provide air quality monitoring and data (the only exception being Ontario where the AQ forecasts are prepared by MOE, (the Ministry of Environment of Ontario). Forecast values of an AQI (Air Quality Index: good, fair, poor or very poor) are usually given in the morning, afternoon and evening of each of the two days in the forecast period (e.g. 48-hour forecast). A special air quality and health advisory is normally issued if values of AQI are expected to be over 50 during the forecast period. Advisory bulletins provide additional health information so that members of the public can take appropriate measures to limit their exposure to outdoor air during poor air quality episodes.

Across Canada, the main themes that regions deal with in order to fulfill and support the AQPP program mandate through projects are basically the same. Those include some monitoring, data analysis, emission, modelling and maintaining the forecast program itself. Nevertheless, regional critical issues depend on where one lives in Canada. For example, in summer, British Columbia, Prairie and Yukon Regions, PM2.5 mainly associated with commercial wood burning and natural forest fires are the main air quality issues although Vancouver and the Lower Fraser Valley also experience some summer smog on occasion due to local sources. In Alberta, the Clean Air Strategic Alliance (CASA), an agreement between Governments and Environmental agencies, dominates the scene of air quality monitoring. In Eastern Provinces, during the warm season, the main concern is the medium- and long-range transport of PM2.5, ozone and their precursors (smog). In winter, domestic wood burning is an issue mainly in Eastern Provinces and has been the driver of the Winter Air Dispersion program. Despite regional differences, provinces and territories have something in common: they are all deeply involved with partners (local and provincial health authorities, federal health institutions, universities, etc.) in developing better monitoring and R&D strategies to better address the problem of air quality and its impact on public health. However, there is a need, mentioned on several occasions during the meeting, to develop better air quality indices. For example, a problem reported by several during the Workshop is that the AQI could be misleading. Many are questioning the validity of attributing a single pollutant as the driver of the AQI. Moreover, AQI does not necessarily say which pollutant causes the AQI to exceed the accepted limit and even if it does, a combination of harmful impacts of pollutants by synergy is not taken into account. Other problems mentioned include how to handle 'anomalous' emissions like wildfires in the context of AQPP programs.

In order to achieve their goals and better meet their mandate, regions participate in working groups such as: National Emission Processing Group, Federal-Provincial Model Application Working Group, AQI Working Group and Real-time monitoring Group to name a few. International support and commitment are also realized through recent projects such as ICARTT and the Border Initiative. An important collaboration to US-Canada has been achieved in almost all regions by feeding ozone, PM2.5 and PM10 data to AIRNOW program. A criticism that has been mentioned in the Workshop is that outreach issues seem to be lacking in Regional Forecast Programs and left to partners such as Lung Association, Health departments, etc.

Atlantic Region (Mike Howe)

The Atlantic Region air quality program provides twice daily air quality forecasts and scientific services for the following provinces: Nova Scotia, New-Brunswick, Prince-Edward Island and Newfoundland (island portion only). The air quality forecast (May-Oct) is accompanied, like in any other regions, by a health advisory and at the times of extraordinary event by an air quality statement (WOCN11/15 messages on AMCIR circuit). A winter dispersion program is also now available in the Atlantic Region. The AQ projects are led by David Waugh and include data analysis and monitoring of mercury, ozone and PM2.5, acidic deposition, the support of data to AIRNOW program, multi-pollutant back-trajectories project, model evaluation (CHRONOS and AURAMS) and an experimental pollen forecast project (in collaboration with Saint Mary`s University). Note that most of the activities of the Atlantic Regions are supposed to be transferred from Fredericton (AQPP) to Darmouth (ASPC) by August 2004.

Québec Region (Jacques Rousseau)

Main activities include real time data access, production of AQ forecast, Airnow program, instrument evaluation, participation in working groups mentioned above (see first section) and special projects. The summer smog forecast program (INFO-SMOG) is based on reports of 41 stations

for ozone and 34 for PM2.5 distributed mainly in Southern Quebec. The program lasts from May to Sept (see message FLCNXX CWUL on AMCIR). The winter air dispersion program (Winter INFO-SMOG) is effective from December to March and applies, for the time being, for the Greater Montréal area only. The forecast itself is based on a statistical model. Future plans include a year round forecast for AQI. Monitoring sites managed by Québec Region are: St-Anicet, l'Assomption, Acadie, Rivière-des-Prairies, St-Faustin and Lemieux. The following parameters are monitored at those sites: ozone, PM2.5, NO_x, sulfur dioxide, carbon monoxide, VOC, PAH and basic meteorological parameters. AQ projects include START (back and forward trajectories update including pollutant emission along trajectory), a guidance document for CWS, the climatology of an interim AQI in Southern Québec, CHRONOS and AURAMS evaluation (ozone and PM2.5), scenarios control, model sensitivity to emissions (high resolution emission field), integration of forest fire emission rates into operational AQ model, etc.

Ontario Region (Douglas Simpson)
The Ontario AQ Forecast Program covers all of Southern Ontario and extends to Sault-Ste-Marie. Ontario is the only province where the AQ forecast is prepared at the provincial level, i.e. by the Ontario MOE (Ministry of Environment) which has its own forecasting team. MSC intervenes only when there is an AQ advisory in effect (messages WOCNXX CWTO). This advisory is issued by Ontario Weather Centre located in Downsview, Ontario. An advisory bulletin is issued when the actual AQI is greater than 50. In the context of the Border Air Quality Initiative, Ontario Region is interested, as a special project, in studying the meso-scale influence of the Great Lakes on air quality.

Prairie and Northern Regions (Brian Wiens, Dave Fox)
The Prairie and Northern Region has a major impact on air quality since this region has a large number of local anthropogenic sources (about 40% of the national total). Fortunately, atmospheric dispersion is often favourable in this part of the country tapering off the acuity of the problem. A big issue is certainly the pollution associated with oil and gas operations (oil sands, McKenzie Valley Pipeline and other oil and gas developments). As a matter of fact, air quality concerns usually tend to be of a localized nature but mostly related to oil, gas or burning wood or crop materials. Projects include the photochemical modelling (using CTM:UAM-V model), source receptors, sensitivity of ozone to biogenics, stratosphere-troposphere exchange (using the Be7 tracer) and analysis constituents of fire smoke (like Banff park prescribed burnings). For the future, the measurement campaign "Prairie 2005" will involve intensive modelling and field study.

Pacific and Yukon (Ted Lord)
Ground-level ozone levels do not pose a significant health risk to the residents of Pacific and Yukon except in the Lower Fraser Valley and Vancouver area. Fine particulates usually associated with wood smoke contribute significantly to air pollution in this region.

Environment Canada developed a Ventilation Index specially to assist the BC Forest Service manage smoke from prescribed burns of forestry waste (slash burns). At times, there are large fires (such as the 2003 Kelowna fires) which can generate huge amounts of smoke (levels of PM2.5 up to 400 micrograms/m^3 reported during Kelowna fires). An air quality forecast is issued once a day (messages FLCN40/FLCN60 CWVR on AMCIR circuit). This forecast gives the AQI for about 16 districts. Furthermore, a smoke control forecast is also provided (messages FLCN39/FLCN79 CWVR). It is basically a 3H prediction of the Ventilation Index for the next 48 hours. The bulletin also includes a forecast of winds and mixing heights. A 3-hour model forecast is also available in winter. Note that Pacific and Yukon Region utilizes a simple bias correction technique for CHRONOS to produce ozone forecasts. There are various data analysis and modelling projects going on in this region. Most revolve around oil and gas or wood burning.

H – Discussion
At the end of each session a few questions were identified by the rapporteurs and chairs of sessions for discussion in a general assembly session. The questions, and the discussion and recommendations that followed, are reported here.

The modelling discussion focused on the 4 following questions: 1) How can we better unify efforts of different air quality (AQ) modelling and data assimilation groups to address international pressures as well as national and regional priorities within the context of an integrated system including linked issues such as climate change, trans-boundary and international pollutant transport? 2) What are the best (most appropriate, most useful) methodologies for evaluating air quality models? 3) Emission inventories are one of the most uncertain components of modelling simulations. How should this be rectified, both in the short term and long term? 4) What are the obstacles hindering more active use of ground-based, in situ, and satellite data by the air quality community?

Four major recommendations were made concerning these issues. First, there is an immediate need to revisit the accessibility and availability of ground- and space-based observed data to AQ modellers. Although the situation has been improving in the past two years, AQ modelling is rapidly evolving in areas such as forecasting and data assimilation which rely on obtaining observed data of good quality in a timely fashion. The recommendation was made to establish a working group which would assess the data needs of AQ modellers, including the need for a single data warehouse, single data format and data exchange standards, international access to the warehouse and queries to international agencies which have restricted access to the data they collect. Surface observations, satellite measurements, profile data of gases and aerosol species as well as optical properties of aerosols were all earmarked as data of interest. The mandate of the working group would be to develop ways to significantly speed up

the current data acquisition and quality check processes of these measurements within a framework similar to the Earth Observing System but in a much shorter time frame as the real time and near real time observation acquisition system needs to be consolidated promptly in Canada.

The use of satellite data was the second emerging issue. Many space-based measurements are now available for use in three-dimensional AQ models but comparisons with surface-based observations are rare. The retrieval of satellite information also includes theoretical and numerical assumptions that need to be verified. Projects aimed at better characterizing and understanding satellite information with respect to AQ models and/or surface-based data were strongly recommended. Following from the discussion on observations, the evaluation of newer AQ models was brought up as a major concern. Sophisticated AQ models are starting to support policy applications while their evaluation process is somewhat ad hoc, leaving a credibility void. This is particularly relevant to policy advisors who often have to defend the AQ models being used prior to or instead of discussing the scientific results and their impacts. Suggestions to improve the evaluation process and make it more visible to the community at large included organizing workshops on model evaluations such as the yearly CMAS workshops in the U.S., benchmarking new models against a common, and available nationwide, dataset, developing a major measurement campaign designed for the purpose of AQ model evaluation (in the spirit of the EMEFS campaign), and investigating new methods for AQ evaluation such as patterns comparison.

Emissions were brought up as the fourth topic of the modelling discussion. Policy advisors and modellers agreed that better communication on emission work across the country and across agencies was required to avoid the current duplicate efforts. The need for a timely access to emission information was also stressed. The participants supported the idea of having a fixed schedule for the release of emission inventories, including a fixed schedule for updates, similar to the EPA process. They also suggested improving the validation process by having an active participation of the provinces in the evaluation process, and implementing an efficient feedback mechanism. Users finally asked to be provided with better information on the uncertainty associated with emission inventories. Low and high estimates of the emission rates that can be used to assess models sensitivity or uncertainty effects on outcomes were specifically referred to. (Update: since the AQA2004, the National Emission Working Group resumed its activities and organized a workshop in Toronto, where the Pollution Data branch discussed the above issues with the AQ modelling community).

Science and policy interactions were the next topic of discussion. Again four questions were up for comment: 1) How can you orient your work to better integrate it to the policy decision-making process? 2) How to ensure uncertainty information is appropriately conveyed to policy makers and public? 3) How can scientists convey the uncertainty inherent in work, such as trajectories, to policy folks? 4) What dialogue is necessary with policy shops to ensure there is appropriate application of scientific advice?

Three recommendations emerged from the participants. Communication between modellers and policy advisors is still an issue and it was suggested to implement a web-based clearing-house for the work being done (especially related to scenarios modelling) and corresponding contact persons. It would also serve as a resource site where policy-makers could find information on models such as description, recommended uses and differences compared to other existing models. The need to educate policy-makers and advisors about the various modelling tools (AQ models and trajectory models), their caveats, and the weight of evidence approach was strongly stressed. The recommendation here was to arrange for lectures at the policy headquarters in Ottawa. Finally AQ models credibility was brought up again as a major concern for policy-makers.

The final theme discussed in the plenary session related to society. To the first question "what is the path forward for improving the air quality model's ability to predict concentrations at the appropriate resolution (e.g., neighbourhood scale) for more realistic population exposure estimates?" The general consensus was that research is just starting on closing the gap between the exposure and the AQ modelling. Fine-scale modelling studies as well as alternate methods to increase field structure through GIS coupling are being developed but more cooperation is required between the two communities to define the appropriate spatial resolution for exposure related modelling work. The second society question directly addressed outreach issues: what are the most effective ways to increase public (e.g., general public, local decision-makers) awareness and interest in taking action to improve air quality? Unfortunately, participants were only able to recognize that outreach programs have been lacking funding despite the high level of information demands generated by the establishment of the air quality prediction program. The only suggestion made was to provide AQ researchers with simple and factual information to give to the public when questioned by the general community.

Although two additional questions related to regional programs were brought forward by the rapporteurs: (1) What is the most urgent need your particular region has in order to better deliver your products to public or clients? (2) How could both CMC and regions better help each other (better adapting output products to regions, creating sub-committees to coordinate efforts, etc.)? It was decided that due to time constraints, those questions would be addressed by internal discussions among region representatives.

Useful web addresses

1) http://lavoieverte.qc.eg.gc.ca/atmos/smog; 2) http://www.msc-smc.ec.gc.ca; 3) http://www.weatheroffice.pyr.ec.gc.ca;
4) http://www.casadata.org; 5) http://www.airqualityontario.com; 6) http://www.rsqa.qc.ca;
7) http://www.al.noaa.gov/ICARTT/regionalairquality.shtml

Definition of acronyms and programs

AIRNOW	Air quality database and real-time products managed by US-EPA	MSC	Meteorological Service of Canada
AQI	Air quality index	NO_x	Nitrogen monoxide and nitrogen dioxide
AQPP	Air Quality Prediction Program	PAH	Policyclic Aromatic Hydrocarbons
ASPC	Atlantic Storm Prediction Centre	PM	Particulate matter
CWS	Canada wide standard	PM2.5	Particulate matter less than 2.5 microns
EPA	Environmental Protection Agency (US)	VOC	Volatile organic compounds

BOOK REVIEW / REVUE de LITTÉRATURE

The Sea's Enthrall: Memoirs of an Oceanographer

by Tim Parsons

Published by EcceNova Editions (www.eccenova.com),
2004, ISBN 0-9731648-8-3 (hardcover) $57.95
ISBN 0-9731648-7-5 (paperback) $27.95, 187 pages.

Book reviewed by William W. Hsieh[2]

This is the autobiography of Tim Parsons, winner of the prestigious Japan Prize for Marine Biology, presented in the presence of the Emperor of Japan in 2001. Tim's achievements have also been recognized by CMOS through the award of the J.P. Tully Medal in Oceanography in 1989.

I found this to be a most enjoyable book to read. The prose flows smoothly between insight and humour, revealing the author's unusual life in its glory and its sadness. Born in Ceylon, Tim tragically lost his father at the age of 3. His destitute mother brought her two children back to England to live with their grandfather. It was to be many decades of toil before the winding path led to the pinnacle of scientific recognition. The lost of two children from illness greatly darkened this path.

After attending boarding school in England, Tim came to Canada in 1949 for his university studies, eventually earning his Ph.D. in Biochemistry from McGill University. He was hired by J.P. Tully to work in Nanaimo, B.C. for the Fisheries Research Board of Canada. After working for UNESCO in Paris and returning to Nanaimo, he eventually became a professor at the University of British Columbia.

Tim's greatest scientific contribution has been his development of a broad holistic vision embracing fisheries and oceanography. As a physical oceanographer, I have always been baffled by the conflicts between fisheries and oceanography. In this book, the titanic forces (economical, political and historical) separating the two disciplines are explained. Tim's long battle against these forces has led to the new science of fisheries oceanography.

The book is also full of lively and amusing portraits, not only of scientists, but also of bungling bureaucrats, corrupt officials and devious taxi-drivers, which gave me many good laughs. In short, this is a delightful, insightful and moving book, which shows Tim to be not only a great scientist, but also a terrific writer.

[2] Professor, Department of Earth & Ocean Sciences, University of British Columbia, Vancouver, BC.

Land Use, Land-Use Change, and Forestry

by R.T. Watson, I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo, and D.J. Dokken (eds).

Cambridge University Press (for the Intergovernmental Panel on Climate Change [IPCC]) 2000
377 pp. ISBN 0-521-80495-7 (paperback, $29.95 US).

Book reviewed by Richard A. Fleming[3]

Greenhouse gases (GHGs) comprise less than 1% of the atmosphere. By trapping the sun's heat near the surface, they provide a natural "greenhouse effect" which raises average global temperatures 33C°, from –19°C to +14°C. Fossil fuel emissions from human activity since the industrial revolution are accelerating the accumulation of GHGs and threaten to warm the planet at rates unprecedented in human history. Mounting evidence suggests that this climatic change is already underway. Left unchecked, it threatens massive destruction of property and lives from a number of directions, including the consequences of global sea level rise, advancing diseases (e.g., malaria), extreme weather (e.g., 15,000 die from France's 2003 heat wave, four times the number lost in 9-11), and most alarmingly, the possible interruption of the Gulf Stream and resultant drop of about 10°C for northern Europe and eastern North America within a 10-20 year period. Canada and 160 other industrialized nations, but not the US (which emits 25% of the GHG excess), have committed to the Kyoto Protocol, the key international agreement to start reducing GHG emissions.

This succinct, well written, well-organized book, a Special Report of the IPCC, focuses on the Kyoto Protocol and how we can slow the rate of GHG accumulation in the atmosphere through land use, land-use change, and forestry (LULUCF) activities. It explains the scientific and technical implications of how such activities affect atmospheric GHG concentrations (particularly carbon dioxide, CO_2) by altering the capacity of the land and its vegetation to store carbon (C). In response to negotiators' concerns, the consequences of adopting different possible definitions and carbon accounting procedures within the Kyoto Protocol are also detailed.

The three part, twenty page summary for policymakers at the start of the book, with numerous cross-references to later chapters, makes for an excellent introductory chapter. Six chapters follow providing the supporting detail and background. Each of these chapters has its own executive summary, introduction, and references. The report closes with three appendices: A (Authors and Expert Reviewers), B (Acronyms, Abbreviations, and Units), and C (List of Major IPCC Reports).

Chapter 1, Global Perspective, provides the current scientific understanding of the global carbon cycle and how human activities have affected it. We learn that atmospheric CO_2 increased by 28% between 1850-1998. This increase accounts for 40% of anthropogenic emissions during this period, the rest being absorbed almost equally between oceans and terrestrial ecosystems.

We also learn how the age of a forest affects its ability to store carbon. Recently disturbed or regenerating areas have trees too small to assimilate carbon fast enough to offset losses from soil respiration. Once established, young stands grow quickly, and by assimilating carbon faster in wood, leaves, and roots than losses through respiration, these stands become carbon sinks. At maturity, such stands have accumulated carbon in wood, roots, soils, and litter but the rate of accumulation (and hence sink strength) has declined. Overmature stands can become carbon sources when respiration from rot and decay becomes substantial. Generally, depending on site conditions and tree species, and allowing for large uncertainties, carbon sequestration may continue for 20-200 years after stand establishment.

Chapter 2, Implications of Different Definitions and Generic Issues, discusses the nuances of alternative possible definitions (e.g., of "forest", "human-induced", "land-use change", "afforestation", "reforestation", and "deforestation") and approaches to carbon accounting (e.g., "land-based", "activity-based", and "project-based") in relation to the Kyoto Protocol. A key issue is "leakage" – that efforts to increase terrestrial carbon storage in one area (e.g., through logging bans) may reduce it elsewhere (e.g., through increased logging to meet regional demands). Another concern is the potential reversibility of biotic carbon storage: disturbances (e.g., insect outbreaks, wildfire, extreme weather) or shifts in management objectives (e.g., deforestation) can suddenly release carbon accumulated in forests over decades. Methodological issues in measuring carbon sequestration and the implications of managing land to store carbon for sustainable development are also considered.

Chapter 3, Afforestation, Reforestation, and Deforestation (ARD) Activities, adds to the discussion of definitions and accounting rules in chapter two. Chapter three shows how calculations of carbon balance can depend critically on the choice of alternative possible definitions and accounting approaches. Calculations based on the most optimistic of these choices suggest that the maximum potential rate of (above and below ground) carbon sequestration from global afforestation and reforestation until 2050 will average 1.1-1.6 Gt/yr. This represents only about 2% of the annual global uptake by the terrestrial biosphere.

Chapter 4, Additional Human-Induced Activities, extends the discussion in Chapter three of LULUCF to the impact of non-ARD activities (e.g., wetland drainage, agroforestry, biofuel production, soil restoration, disturbance

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[3] Research Scientist, Canadian Forest Service, Sault Ste. Marie, ON.

management, fertilization, irrigation, etc.). Although such additional activities are important, we are told that they alone aren't enough to offset the GHG effects of fossil fuel emissions. The chapter aims to guide negotiators on questions of which additional human-induced activities to add to the agreement and how to do it.

Chapter 5, Project-Based Activities, describes the characteristics of LULUCF projects for mitigating GHG emissions and delves into the practical details of implementing them within the Kyoto Protocol. These projects involve protecting or increasing terrestrial carbon stocks, or substituting biomass for fossil fuels and energy-intensive materials (e.g., cement, steel, plastic, bricks). A review of current projects found that carbon stocks were augmented by 4-440 t/ha over the project's duration at a cost of $US 0.1-28 /t.

Chapter 6, Implications of the Kyoto Protocol for the Reporting Guidelines, deals with the technicalities of achieving verifiable and transparent reporting of national GHG inventories. One quickly becomes mired in legalistic detail here.

Overall, I'm favourably impressed by this balanced, thorough, and authoritative book. Concepts are well described and often illustrated by figures or tables, but it is not light reading. Fortunately, the book's structure allows readers to find sections of particular interest rather easily, although an index would make this easier still. There is great detail in the book, but it is important, and one of the reasons I think this book would make a useful reference for undergraduates, graduates, policymakers, environmental groups, business leaders, and faculty in various disciplines of environmental study. Reading between the lines, one can also glimpse the complexities of negotiating international scientific agreements.

Dynamics of the Atmosphere: A Course in Theoretical Meteorology

by Wilford Zdunkowski and Andreas Bott

Cambridge University Press, April 2003
Soft cover; ISBN 0 521 00666 X ; 719 pages ;
CDN$ 84.00

Book reviewed by Adam Monahan[4]

This book presents a mathematically sophisticated introduction to dynamic meteorology. With its companion volume on atmospheric thermodynamics, it is intended to act as the basis of a course on theoretical meteorology.

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[4] Assistant Professor, School of Earth and Ocean Sciences, University of Victoria, Victoria, BC.

"Dynamics of the Atmosphere" is divided into two parts. The first is a detailed (130 page) introduction to the mathematical tools that will be used to approach the study of dynamic meteorology. These tools are developed so that the equations of motion can be expressed in arbitrary curvilinear coordinate systems. In this mathematically highly formal presentation, vector algebra and functions come first. Following is a discussion of differentiation and coordinate transformations in arbitrary coordinate systems, which leads into an overview of integral theorems. Part 1 ends with a brief introduction to dynamical systems and bifurcation theory.

While this mathematical introduction is undeniably thorough, it is also very formal. Concepts and operations are generally introduced without any motivation, which is a shame, as many of these ideas have intuitive geometrical interpretations. As well, there is a marked absence of intuition-building applications of these complicated constructions and ideas to simple cases: rather than starting from a foundation of relatively simple ideas and generalising upwards, the discussion starts from the most general result and works down from there. Working through Part 1 will be a hard slog for readers without a good background in general relativity, so its pedagogical utility for a typical graduate course in atmospheric science is limited. This being said, Part 1 contains a number of valuable results and proofs that I haven't been able to find in other dynamical meteorology texts, and which will be of considerable use for my graduate lectures.

The discussion of atmospheric dynamics begins in Part 2 of this book, and the development follows a fairly standard progression: basic fluid dynamics, boundary conditions, circulation theorems, turbulence and the atmospheric boundary layer, wave motion, barotropic dynamics, Rossby waves, inertial and dynamic stability, the equations of motion in different coordinate systems (including a detailed discussion of stereographic and orography-following coordinates), quasigeostrophy, baroclinic instability, numerical methods (briefly), and predictability. In general, the presentation of the basic material is also fairly standard, although somewhat encumbered by the notational baggage inherited from Part 1. Notable exceptions are the discussion of boundary conditions, which I found innovative and illuminating; and the discussions of turbulence and the atmospheric boundary layer, which included detailed discussions of interesting and useful material not often included in standard texts on dynamical meteorology. As in Part 1, the presentation of material is generally quite thorough, but formal. Little effort is made to communicate an intuitive feel for the atmosphere as a physical system, and theoretical results are rarely connected to observed atmospheric motions. I will illustrate this point with two examples. First, in the chapter on Rossby waves, there is no discussion of the mechanism by which they arise. The simple picture of a chain of fluid parcels displaced alternately poleward and equatorward away from an initial latitude band, acquiring relative vorticity through conservation of absolute vorticity so that the pattern

propagates westward, is immensely useful for developing physical intuition - but nothing like it appears in this book. Instead, Rossby waves are presented solely as solutions to the linearised equations of motion. Second, at no point is baroclinic instability related to the meridional transport of energy by midlatitude cyclonic systems or to the role these processes play in maintaining the climatological equator to pole temperature gradients. In the absence of such a discussion, a student new to the discipline might see baroclinic instability simply as a curiosity of the meteorological equations of motion rather than a fundamental physical process associated with the weather so familiar to those of us living underneath the storm tracks.

Two further minor criticisms of this book are firstly, that it frequently references the companion volume, so it is not a stand-alone text, and secondly, that it often cites texts or articles that are available only in German, and so are not accessible to a broad international audience. In summary, I believe that this book will be a valuable resource for practitioners in the field of atmospheric science, but it is of limited utility as a textbook. It is generally clear and well-written, but focuses too much on mathematical formalism and not enough on the atmosphere as a physical system.

Environmental Change, Climate and Health, Issues and Research Methods

Edited by Pim Martens and Anthony J McMichael

Cambridge University Press, 338 pages
ISBN 0-521-78236-8, (hard cover, US$90.00)

Book reviewed by Sharon Jeffers[5]

The goal of this book is to provide a multi-disciplinary look at the issues of environmental change, including climate change, and the health issues arising from these changes. Each chapter is written by a different author or authors, who cover a variety of topics such as the historical connections between climate, medicine and human health, standard epidemiological techniques, the ENSO cycle and disease, and dealing with scientific uncertainty and risk perception. While many of the authors have a background in epidemiology or public health, there are enough authors from other scientific disciplines to make the book more than just a treatise on epidemiology.

I have to admit, I found the first part of the book heavy going. Everything I read seemed to fall under the category of somewhat interesting and good to know, but nothing really fired my imagination or enthusiasm. Nor did I see a strong link in the first half of the book between climate and health. Then I reached chapter six, and things got interesting (there are a total of twelve chapters in the book).

Chapter 6 is on analogue approaches to describing climate variability and health. A lot of the problems described by the authors in doing retrospective studies on climate variability and health resonated with me, especially the paucity of time series data on disease. Current epidemiological techniques (covered in chapter five) deal best with health impacts of daily, weekly or monthly variability, and require only a few years' worth of health data. Apparently, we lack enough accurate, long-term disease data to study the effects of gradual change in mean climate. To further complicate matters, climate is not the only factor to be considered; land use changes and improved health care being just two such factors. Chapter six also deals with the issue of climate variability versus climate change. In spite of the problems associated with carrying out retrospective studies, several clear and easily understandable examples of such studies are given, including the ENSO and its potential as an analogue for climate change and health effects. The authors see analogue studies as one of many tools in the climate change/health tool box.

I found the last half of this book (chapters six to twelve), much more interesting and concrete. I could always relate to what was written and had no trouble seeing the potential application of the subject matter in each chapter. These chapters covered integrated assessment modelling of human health impacts, GIS and its uses, monitoring health impacts now for use as baselines and to learn techniques we can apply in the future, and the epidemiological approach. As a meteorologist interested in this area, I have found a need to further my understanding of epidemiology. Chapter eleven on the epidemiological approach to environmental health and global change was very useful for me in this regard. I thought ending the book with a chapter of scientific uncertainty and risk perception was a great closing for the book. It is not enough to do the science; we must share that science with the rest of the world, and here especially in the area of climate change, not just the public, but politicians and policy-makers. What we do must be understandable to people. It is not a question of using words with fewer syllables, we also need to consider the cultural and societal differences that will affect understanding of the issues. Chapter twelve deals with all this, as well as giving an introduction to risk perception, an emerging field of study itself.

On the whole, I found the book gave me a lot of good information on the topic, in spite of the slow start. The readability varies, as there are many authors, as well as a wide variety of topics. I would recommend the book for anyone with an interest in the interaction between climate and health. This is a fairly expensive book, so unless you are very keen indeed, it might be better to take it out of the library (providing you can find it there, of course). Any one chapter of particular interest can be read out of context with no loss of understanding.

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[5] Meteorological Service of Canada, Montréal, QC

CMOS NEWS

Members Only section on CMOS Website

CMOS has started to implement various web interfaces modules to allow members to interact with the membership database in order to update their coordinates (address, telephone, fax), their personal preferences (interests, language of correspondence, permission to list their address), to access the On-line Directory (to search for other members), to renew membership, to register to meetings, to submit abstracts to meetings and to subscribe to publications (these last three functions will also be available to non-members). The modules are being implemented progressively this summer and fall.

The Members Only section is found at the bottom of the main page of the CMOS web site and is accessible by means of a username and password unique to each member. Your username is composed of the first 6 letters of your surname (or less if it is shorter), followed by your two-to-four-figure membership number, which appears at the top left of the mailing label of your CMOS Bulletin SCMO. Your initial password is your membership number. There is a function in the "My Coordinates" module to change your password to one of your choice.

We have taken steps to protect your privacy. Although it will appear as if the access to the database is direct and might be susceptible to unauthorised entry, in reality the database resides on a secure server, located in a secure building and is protected by two firewalls and your password. Communications through the web modules are encrypted.

In designing the On-line Directory and the page where you consent to list some elements of your address, we made a small change to the questions that we have traditionally asked on the membership renewal form. You now have the choice of having any or all of the components of your coordinates listed in the Directory. To protect your privacy, the default setting is to list only your name. However, we would like to encourage each of you to consent to listing some elements of your address, so that other members have at least one way to contact you. Remember, only members have access to the Directory.

In the Consent page, you also have the option of removing your name from the mailing list that we use occasionally to send you book offers or other similar advertising that we judge to be in your interest. Please note that the policy of CMOS is to not sell or rent our mailing list to any other organization.

We hope that the Membership Renewal module will become the main method of renewal. To make this tool effective, we encourage all members to visit the Members Only section and update their coordinates regularly. If we have a valid e-mail address for you, we will use it to the extent possible to contact you.

The first use of the Meeting Registration and Abstract Submission modules will be in conjunction with the 2005 Annual Congress, in Vancouver BC. It is our intention, for the first time, to offer congress organizers the service of the CMOS Executive Office for registration administration. This is a service that has been requested for many years, but that we could not offer before we acquired the necessary tools. Although there is an investment required to set up this service, we expect that it will quickly pay for itself. We thus hope that the task of organizing a congress will become easier and more appealing for smaller Centres.

On-line users will be able to purchase a username and password for access to ATMOSPHERE-OCEAN On-line (see more below about subscriptions). The electronic sales module will also permit on-line sales of other products.

In the future, the Members Only section can be used to exchange several other communications that we wish to remain secure within the membership. Your suggestions to this effect are solicited.

Postal Supplements

Postal supplements were approved recently by the CMOS Annual General Meeting and by the CMOS Executive Committee. The new rates apply to foreign members and subscribers as shown below :

2005 Prices for ATMOSPHERE-OCEAN

Postal rates have increased significantly in 2004; delivery by regular mail outside of Canada is slow; the electronic version of ATMOSPHERE-OCEAN is gaining popularity at the expense of the printed version. For these reasons, we have decided to use only air mail for delivery outside of Canada, and adjusted our prices for 2005 accordingly.

Effective 1 January 2005

The CMOS web site www.cmos.ca will provide free access to the index and abstracts of papers only (NO FULL TEXT).

Our new prices for ATMOSPHERE-OCEAN (A-O) are as follows:

ATMOSPHE-RE-OCEAN	ELECTRONIC FORMAT ONLY	ELECTRONIC and PRINTED (Shipped by airmail outside Canada)	CD-ROM (Includes more than A-O) Disk1: 1978-1995 Disk2: 1988-2004
INDIVIDUAL SUBSCRIP-TION (all countries)	$15	$45	$20 per disk
INSTITU-TIONAL SUBSCRIP-TION	$110	Canada: $125 U.S.A.: $145 Overseas: $180	$50 per disk

1) Subscription to A-O ELECTRONIC FORMAT ONLY is valid for one year from time of purchase. No access will be available without an up-to-date subscription.

2) The ELECTRONIC format includes the full text of all papers since 1978. The papers are fully searchable in pdf format.

3) Subscription to A-O ELECTRONIC AND PRINTED includes the four printed issues (MAR, JUNE, SEPT and DEC) plus access to A-O ELECTRONIC for the 15 month period from 1 JANUARY of the subscription year to 31 MARCH of the following year.

A-O CD-ROM contains the following, all specially indexed to ensure rapid searches by author, title or any word or expression in general:

- the same electronic files as A-O ELECTRONIC;
- the complete contents of the book *Numerical Methods in Atmospheric and Oceanic Modelling: The André Robert Memorial Volume (1997)*; and,
- Abstracts of the papers presented at a number of Annual CMOS Congresses (1997, 1999, 2001-2004).

Shipping of A-O CD is by regular mail; air-mail is $5 extra.

2005 Prices for *CMOS Bulletin SCMO* and for Foreign Membership

Postal rates have increased significantly in 2004; delivery by regular mail outside of Canada is slow. For these reasons, we have decided to use only air mail for delivery outside of Canada, and adjusted our prices for 2005 accordingly.

Effective 1 January 2005

Memberships fees (as well as the cost of a separate subscription to *CMOS Bulletin SCMO*) will be:

CANADA	U.S.A.	OVERSEAS
$60	$75	$100

NOUVELLES de la SCMO

Section du site web pour les membres seulement

L'implantation de divers modules d'interface web a débuté, ce qui permettra aux membres d'accéder à la banque de données sur les membres pour mettre à jour leur coordonnées (adresse, téléphone, fax, courriel), leurs préférences personnelles (intérêts, langue de correspondance, permission d'inscrire leur adresse sur la liste), accéder au répertoire en-ligne (recherche d'autres membres), renouveler l'adhésion, s'enregistrer à une réunion, soumettre un résumé à une conférence, ou s'abonner à une publication (ces trois dernières fonctions seront accessibles aux non-membres). Les modules seront implantés graduellement au cours de l'été et de l'automne.

La section pour membres seulement se trouve au bas de la page principale du site SCMO, et est accessible grâce à un nom d'usager et mot de passe unique à chaque membre. Votre nom d'usager est composé des six premières lettres de votre nom de famille (ou moins, si il est plus court) suivi de votre numéro de membre de deux à quatre chiffres, qui apparaît en haut à gauche de l'étiquette de votre CMOS Bulletin SCMO. Votre mot de passe initial est votre numéro de membre. Il y a une fonction dans le module des coordonnées, pour changer votre mot de passe à un mot de votre choix.

Nous avons pris des mesures pour protéger votre dossier personnel. Même si vous aurez l'impression que l'accès à la banque de données est direct et susceptible d'accès non autorisé, en réalité la banque de données réside sur un serveur sécurisé, gardé dans un site sécurisé et protégé par deux coupe-feu ainsi que votre mot de passe. Enfin, les communications au moyen des modules web sont codées.

Dans la conception du répertoire en-ligne et de la page où vous donnez votre consentement pour afficher certains éléments de votre adresse, nous avons fait un petit changement aux questions que nous avions l'habitude de poser sur le formulaire de renouvellement d'adhésion. Vous pouvez maintenant permettre l'affichage de n'importe quel élément des éléments de vos coordonnées. Pour fins de sécurité, la décision par défaut est d'afficher votre nom seulement. Cependant, nous vous engageons à consentir à permettre l'affichage de quelques éléments, afin d'offrir à vos collègues au moins un moyen de vous contacter. N'oubliez pas que seuls les membres ont accès au répertoire.

À la page de consentement, vous avez aussi l'option de soustraire votre nom des listes d'adresses que nous utilisons occasionnellement pour vous envoyer des offres de livres ou autres annonces du genre, que nous jugeons dans votre intérêt. Veuillez noter que la politique de la SCMO est de ne pas vendre ou louer sa liste d'adresses à aucune organisation.

Nous espérons que le module de renouvellement d'adhésion deviendra la voie principale de renouvellement. Pour que cet outil soit efficace, nous souhaitons que tous les membres visitent régulièrement la section pour membres seulement et mettent à jour leur profil. Si nous avons une adresse courriel à jour pour vous, nous l'utiliserons autant que possible pour vous contacter.

Les modules d'enregistrement à une réunion et de soumission de résumé seront utilisés pour la première fois en conjonction avec le Congrès annuel de 2005, à Vancouver CB. Nous avons l'intention, en grande première, d'offrir aux organisateurs du congrès les services du Bureau exécutif pour l'administration des enregistrements. Il s'agit d'un service qui est demandé depuis plusieurs années mais que nous ne pouvions pas offrir avant d'avoir acquis les logiciels nécessaires. Quoique des investissements soient requis pour mettre ce service sur pieds, nous nous attendons à ce qu'ils se payent rapidement. Nous espérons ainsi de rendre la tâche d'organiser un congrès plus facile et plus attrayante pour les petits centres.

Les utilisateurs en ligne pourront acheter un nom d'usager ainsi qu'un mot de passe pour ATMOSPHERE-OCEAN en ligne (voir plus bas au sujet des abonnements). Le module de ventes électroniques nous permettra aussi de vendre d'autres produits en ligne.

À l'avenir, la section pour membres seulement pourra être utilisée pour l'échange d'autres communications que nous voulons effectuer en sécurité entre nous. Vos suggestions à cet effet sont les bienvenues.

Suppléments Postaux

Des suppléments postaux ont été approuvés récemment par l'Assemblée générale annuelle et l'Exécutif de la SCMO. Les nouveaux taux, qui s'appliquent aux membres et aux abonnés étrangers, apparaissent ci-bas :

Prix pour ATMOSPHERE-OCEAN en 2005

Les frais de poste ont beaucoup augmenté en 2004; la livraison à l'extérieur du Canada par la poste ordinaire est lente; la version électronique de ATMOSPHERE-OCEAN gagne en popularité au dépend de la version imprimée. Pour ces raisons, nous avons décidé de n'utiliser que le courrier aérien pour la livraison hors du Canada, et avons ajusté nos prix pour 2005 en conséquence.

À compter du 1 janvier 2005

Le site de la SCMO www.scmo.ca ne fournira l'accès gratuit qu'à l'index et aux résumés des articles (AUCUN TEXTE INTÉGRAL).

Nos nouveaux prix pour ATMOSPHERE-OCEAN (A-O), sont les suivants:

ATMOSPHE-RE-OCEAN	FORMAT ÉLECTRONIQUE SEULEMENT	ÉLECTRONIQUE et IMPRIMÉ (poste aérienne hors du Canada)	CÉDÉROM (inclut plus que A-O) Disque 1: 1978-1995 Disque 2: 1988-2004
ABONNE-MENT INDIVIDUEL (tous les pays)	15$	45$	20$ par disque
ABONNE-MENT INSTITUTIONNEL	110$	Canada: 125$ U.S.A.: 145$ Outremer: 180$	50$ par disque

1) L'abonnement à FORMAT ÉLECTRONIQUE SEULEMENT est valide pour un an à partir de la date d'achat. Aucun accès ne sera possible sans un abonnement à date.

2) Le format ÉLECTRONIQUE inclut le texte intégral de tous les articles depuis 1978. On peut faire des recherches à partir des fichiers .pdf.

3) L'abonnement à A-O ÉLECTRONIQUE ET IMPRIMÉ inclut les quatre numéros (mars, juin, septembre et décembre), ainsi que l'accès à A-O ÉLECTRONIQUE pour la période de 15 mois débutant le premier janvier de l'année de l'abonnement jusqu'au 31 mars de l'année suivante.

Le CÉDÉROM A-O contient les fichiers suivants, spécialement indexés pour assurer des recherches rapides selon l'auteur, le titre ou tout mot ou expression en général:

- Les mêmes fichiers électroniques que A-O ÉLECTRONIQUE;
- Le contenu intégral du livre *Numerical Methods in Atmospheric and Oceanic Modelling: The André Robert Memorial Volume (1997)*; et

■ Les résumés des présentations à plusieurs des congrès de la SCMO (1997, 1999, 2001-2004).

Le CÉDÉROM A-O est livré par la poste régulière. Le courrier aérien est disponible avec un supplément de 5$.

Prix du *CMOS Bulletin SCMO* pour 2005 et l'adhésion des membres étrangers

Les frais de poste ont beaucoup augmenté en 2004; la livraison à l'extérieur du Canada par la poste ordinaire est lente. Pour ces raisons, nous avons décidé de n'utiliser que le courrier aérien pour la livraison hors du Canada, et avons ajusté nos prix pour 2005 en conséquence.

À compter du 1 janvier 2005

Les frais d'adhésion pour les membres (ainsi que le prix d'abonnement séparé au *CMOS Bulletin SCMO*) seront:

CANADA	U.S.A.	OUTREMER
60$	75$	100$

Atmosphere-Ocean 42-3 Paper Order

AO-510
Interaction of Climatic Variability with Climatic Change.
by B.G. Hunt and T.I. Elliott

AO-408
Changes in Winter Cyclone Frequencies and Strengths in Transient Enhanced Greenhouse Warming Simulations Using Two Coupled Climate Models
by Steven J. Lambert.

AO-416
Variability of Surface Heat Flux over the Indian Ocean
by Hiroyuki Tomita and Masahisa Kubota.

AO-517
Application of Wavelet and Regression Analysis in Assessing Temporal and Geographic Climate Variability: Eastern Ontario Canada as a Case Study
by Andreas Prokoph and R. Timothy Patterson.

OC-253
A Coupled Model Simulation of Ocean Thermohaline Properties of the Last Glacial Maximum
by Seong-Joong Kim.

CMOS Vision Paper (updated, 2004)

A pdf (Acrobat) version of *"CMOS in 2003/2004 and its Future"* has been posted on the web at www.cmos.ca. Please look under "About CMOS" or in the Web Site Index.

Document de réflexion de la SCMO (mise à jour, 2004)

Une version pdf (Acrobat) du document *"La SCMO en 2003/2004 et son avenir"* a été affichée sur la toile à www.scmo.ca. S'il-vous-plaît, chercher sous "À propos de la SCMQ" ou "Index du site" .

Important Notice to ATMOSPHERE-OCEAN Readers

Please note that there will be major changes to A-O on-line as of 1 Jan 2005, specifically: the complete archive of full papers will be available, but only paid subscribers will have access to full texts. In the near future, we will be offering the possibility to subscribe on-line at the cost of $15 per year. Please see complete details at:

http://www.cmos.ca/pubspricesinfo.html#A1

Avis important aux lecteurs d'ATMOSPHERE-OCEAN

Veuillez noter qu'il y aura des changements importants à A-O en ligne à partir du 1 janvier 2005, spécifiquement: l'ensemble complet de tous les textes intégraux sera disponible, mais seuls les abonnés auront accès aux textes complets. Nous offrirons sous peu la possibilité de vous abonner en ligne au coût de $15 par année. Veuillez lire tous les détails à:

http://www.cmos.ca/pubspricesinfof.html#ATMOSPHERE-OCEAN

"All theorem are true. All models are wrong.
All data are inaccurate. What are we to do?"

L.Smith

IMPROVING ACCESS to DFO DATA

The DFO GeoPortal, recently upgraded and available at http://gp2.chs-shc.dfo-mpo.gc.ca, provides access to the publicly available data of Fisheries and Oceans Canada. GeoPortal comprises numerous tools and services to address the requirements of a broad audience, both internal and external to DFO. Tools available on this site provide pre-defined dynamic views that are made up of DFO data combined with data from other government and private organizations. GeoPortal is compliant with the Open GIS Consortium (OGC) specifications.

ARCTIC CORING EXPEDITION 2004

The six-week Arctic Coring Expedition (ACEX) is an inaugural effort of the international Integrated Ocean Drilling Program (IODP). An expedition at the North Pole will study the geological history of the Arctic Ocean. By examining sediments recovered from beneath the seafloor, itself a technological and engineering feat, scientists will uncover and reconstruct the evolution of climate and environmental conditions of the past 50 million years. For information, access http://www.rcom-bremen.de/English/IODP.html

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SHIP-SINKING MONSTER WAVES

The European Space Agency ERS satellites have helped to confirm the widespread existence and relative frequency of 'rogue' waves of up to 30 metres. This has major safety, economic and environmental implications since current ships and offshore platforms are designed to withstand maximum wave heights of only 15 metres. The European Union-sponsored MaxWave programme which concluded in 2003 has now been superseded by the WaveAtlas programme which will create a worldwide atlas of rogue wave events and carry out statistical analyses. For more details, please access http://www.esa.int/export/esaCP/SEMOKQL26WD_Protecting_0.html

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WESTERN CANADA WEATHER WORKSHOP

The 8th annual Western Canada Weather Workshop will be held at the University of British Columbia main campus on 14 October 2004. Its theme is operational weather forecasting for Western Canada and neighbouring regions. This workshop is designed to bring together industry, government, and academia to discuss current issues, weather events, and advances in regional weather prediction.

The workshop is co-organized by Environment Canada's Pacific Yukon Region (Laurie Neil) and by the University of British Columbia (Roland Stull), and is partly sponsored by the CMOS BC Lower Mainland Centre (Rich Pawlowicz, president). The location is room 330A of the Earth and Ocean Science Building main wing, starting at about 8:30 am. For more information, please access http://weather.eos.ubc.ca/events/WCWW04/wcww04.html

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OCEAN INNOVATION 2004

Ocean Innovation 2004 is scheduled for 25-26 October 2004 in Victoria, BC. The theme for this year's event is "Achieving a Balance: Ocean Development and Environmental Health". The Conference will focus on various aspects of innovation in the ocean environment, among them, issues related to technology, investments, partnerships and human resource requirements. Two concurrent Workshops are scheduled offsite on 27 October: "Maritime Simulation" and "Marine Remote Sensing". For more information, please access http://www.oceaninnovation.ca/.

A CANADIAN PERSPECTIVE on CLIMATE CHANGE

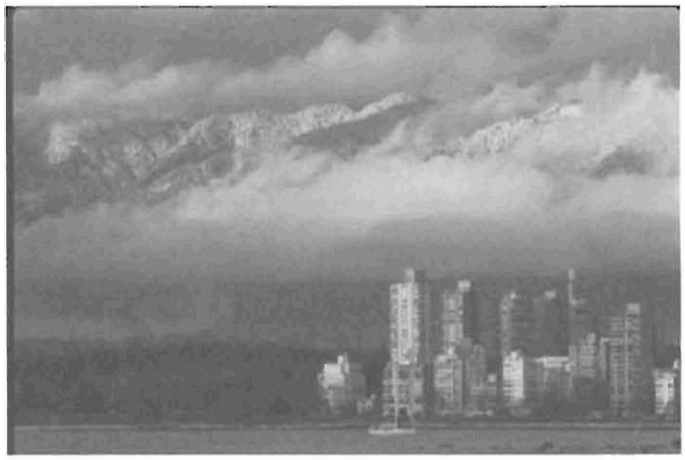
The report entitled "Climate Change Impacts and Adaptation: A Canadian Perspective", prepared by the Climate Change Impacts and Adaptation Directorate of Natural Resources Canada, provides an overview of key climate change concerns within several major Canadian sectors, including coastal zones, based on studies published over the past five years. The report is available at http://adaptation.nrcan.gc.ca/perspective_e.asp.

HURRICANE TRACKING

The Canadian Hurricane Centre provides information on storms of tropical origin that affect Canada or its territorial waters. The Centre's website located at http://www.hurricanecentre.ca provides the latest hurricane and tropical storm watches and warnings, hurricane track information, hurricane storm summaries, satellite photos, radar images, along with a wide range of information related to the science of hurricanes. The US National Hurricane Center website at http://www.nhc.noaa.gov provides similar information for the Atlantic Ocean, Caribbean Sea, Gulf of Mexico, and the Eastern Pacific.

OCEAN YEARBOOK VOLUME 18

Published in cooperation with the International Ocean Institute and Dalhousie University Law School, Ocean Yearbook 18 - a commemorative volume honoring Elisabeth Mann Borgese - presents original, peer-reviewed articles, reviews, and reference materials from experts in governance and sustainable development, integrated coastal and ocean management, global and regional cooperation, and international law and environmental policy. For information on purchasing the Ocean Yearbook, access http://www.press.uchicago.edu/cgi-bin/hfs.cgi/00/16415.ctl



39th CMOS Annual Congress: Sea to Sky

Vancouver, British Columbia, Canada
May 31 - June 3, 2005

Members of the Canadian Meteorological and Oceanographic Society and other interested persons are invited to submit abstracts for oral and poster presentations at the 39th CMOS Congress to be held near Vancouver, BC, Canada. The abstract submission date has been set for **Friday, February 18, 2005.** A full call for papers will appear in the next issue of the *CMOS Bulletin SCMO.*

For more information about the Congress including a full listing of special sessions, please visit the website at www.cmos2005.ubc.ca. Persons interested in organizing a special session should contact the Chair of the Scientific Program Committee, Rich Pawlowicz at rich@eos.ubc.ca

39e Congrès annuel de la SCMO
Entre ciel et mer

Vancouver, Colombie Britannique, Canada
du 31 mai au 3 juin 2005

Les membres de la Société canadienne de la météorologie et de l'océanographie et toutes autres personnes intéressées sont invités à soumettre un résumé pour des présentations orales ou pour des affiches au 39e congrès de la SCMO qui se tiendra près de Vancouver, CB, Canada. La date butoir pour la soumission des résumés a été fixée au **vendredi, le 18 février 2005.** Une demande de communications plus détaillée sera présentée dans le prochain numéro du *CMOS Bulletin SCMO.*

Pour plus de renseignements à propos du congrès incluant une liste des sessions spéciales, prière de visiter la toile à www.cmos2005.ubc.ca. Les personnes intéressées à organiser une session spéciale doivent contacter le président du Comité du programme scientifique, Rich Pawlowicz à rich@eos.ubc.ca

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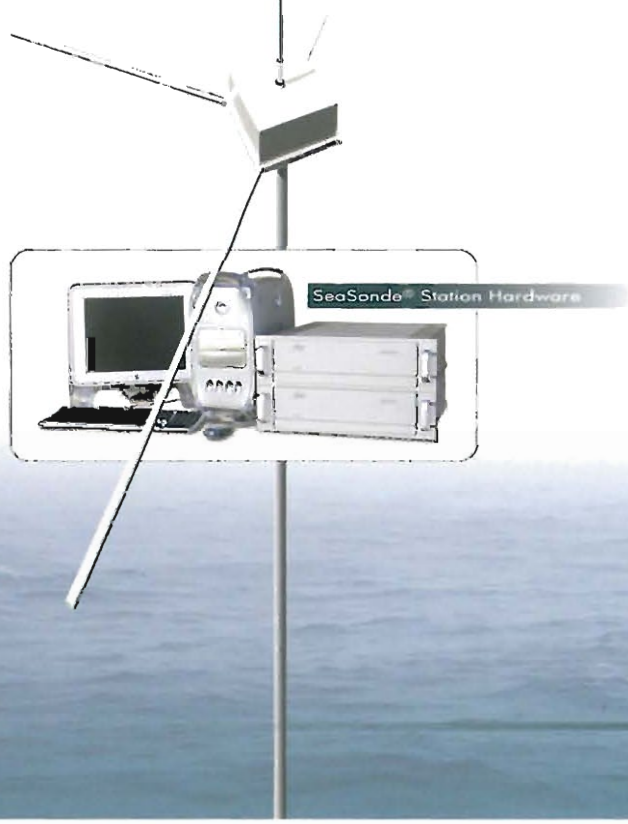

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