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Canadian Meteorological and Oceanographic Society

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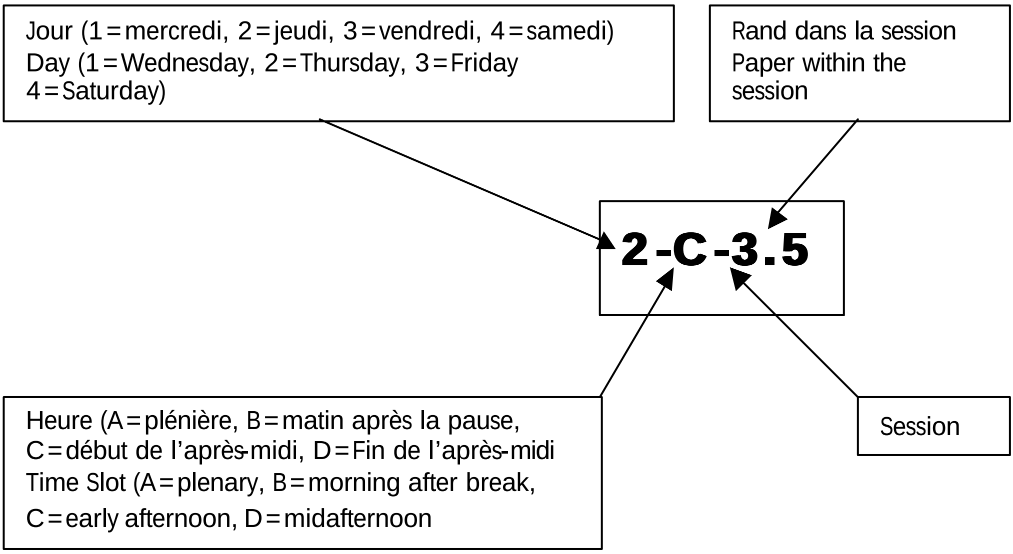

1-A-1

Polar Ecosystems as Sentinels of Global Change

Écosystèmes polaires comme sentinelles des changemetns environnementaux à l'échelle planétaire

Warwick Vincent

Centre d'études nordiques, Université Laval, Québec, Québec, Canada

Global circulation models converge on the prediction that the climate change is likely to be observed most strongly in the north and south polar regions, and high latitude ecosystems are especially sensitive to small changes in the precarious balance between freezing and thawing. These features make polar ecosystems attractive sites for monitoring global change, but they also result in an enhanced sensitivity to interannual and other scales of natural variability that can obscure long-term trends caused by anthropogenic forcing. This talk examines examples of ecosystems that offer valuable potential, but also challenges, as sentinels of change. Our research on far northern lakes indicates the recent loss of perennial ice, with major implications for the structure and function of these ecosystems. Previous climate-induced changes in the vegetation of northern Canada throughout the Holocene have led to major shifts in the properties of lakes, rivers and coastal marine ecosystems of the region. Our paleo-optical observations and modelling results show that these effects include changes in the underwater biological exposure to ultraviolet radiation that are much greater than those caused by moderate ozone depletion. Antarctic ozone depletion has provided a strong signal of global, human-induced change in the upper atmosphere, however past and present climate effects in south polar ecosystems are less clear. Contrasting patterns of temperature change and ecosystem responses have been recently been announced at two sites in Antarctica, indicating the need for regional models of climate change and sensitivity, as well as the difficulties of extrapolating from short-term time series. Finally, our work on Arctic ice shelves at latitude 83N along the northern coast of Ellesmere Island shows the major loss of unique cryo-ecosystems over the course of the 20th century. Monitoring of the remaining ice-bound habitats in this region, for example by RADARSAT, will provide an ongoing guide to the pace of environmental change.

1-B-1.1

Tropical links of the Arctic Oscillation

Hai Lin[1], Jacques Derome[1], Richard Greatbatch[2], Andrew K. Peterson[2] and, Jian Lu[2]
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A primitive equation dry atmospheric model is used to investigate the origin of the Arctic Oscillation (AO). A series of integrations is made for 51 winter seasons (DJF) from 1948/49 to 1998/99. For each winter the model uses a time-averaged forcing field that is calculated empirically from the National Centers for Environmental Prediction (NCEP)/National Center for Atmospheric Research (NCAR) reanalyses daily data during the winter in question. Ensembles of simulations are done for each winter. The ensemble mean of the simulations reproduces much of the observed AO variability. Two additional sets of experiments are conducted. In one case the interannually varying forcing is prescribed only in the tropics, while in another it is prescribed in the extratropics only. These simulations indicate that a significant part of the interannual variability of the wintertime AO, as well as its trend, are linked to the tropical forcing field. The extratropical forcing plays no role in reconstructing the AO variability.

1-B-1.2

Evidence of nonlinear dynamics in the eastward shift of NAO

Andrew K. Peterson, Jian Lu, and R.J. Greatbatch.
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Hilmer and Jung [2000] have identified an eastward shift in the SLP pattern associated with the NAO in the period 1978-1997 as compared to the earlier period 1958-1997. This has important implications with regards to ice export from the Arctic into the North Atlantic.
Using a primitive equation, dry atmospheric model with a rudimentary representation of the model physics we have attempted to model each winter of the period 1949-1999 using diabatic forcing diagnosed from NCAR/NCEP reanalysis data. Using this forcing, the model is able to reproduce the eastward shift. The model also reproduces the eastward shift with forcing that has been regressed against the winter NAO index, showing that the eastward shift is a consequence of non-linear dynamical processes. Finally, using both observations and model results, we will show that the eastward shift is present during periods of both extreme high and extreme low NAO index.

1-B-1.3

The changing relationship between the NAO and northern hemisphere climate variability

Jian Lu and R.J. Greatbatch
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Sea level pressure (SLP) difference across Fram Strait is used as a proxy for ice export through the Strait to verify that a secular change in the link between the NAO and Fram Strait ice export occurred around 1980, and that the change was associated with an eastward shift in the SLP pattern associated with the NAO. Two additional variables, Siberian winter temperature, and an index of North Atlantic storm activity, are also found to switch from being uncorrelated with the ice export proxy in the 1950's and 60's to being strongly correlated in the 1980's and 90's, suggesting the emergence of a new climate regime associated with the NAO. We argue that the establishment of this new climate regime is related to an upward trend throughout the whole of the 20th century in

the cross-correlation between the NAO index and Rogers' first storm activity mode for the North Atlantic.

1-B-1.4

The effects of the NAO on summer precipitation and freshwater discharge over Canada

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The North Atlantic Oscillation (NAO) is a most prominent atmospheric teleconnection pattern with decadal timescale. It is the dominant mode of winter climate variability in the North Atlantic region on a monthly timescale. The NAO plays an important role with respect to precipitation, temperature, Atlantic storm tracks and oceanic salinities. Freshwater inputs exert a large impact on the circulation of the Arctic and North Atlantic Oceans, and thus on the global circulation. To understand the effects of the NAO on summer precipitation and freshwater discharge, we use NCAR/NCEP daily reanalysis data to analyze the atmospheric general circulation and moisture transports. Decadal variability is found associated with Canadian regional precipitation patterns. These patterns are found to be associated with a dipole of geopotential height anomalies, produced by the different phases of the NAO. The changes in precipitation to correlate with the freshwater discharge from a number of important Canadian rivers are shown. It is found that the decadal variability of precipitation over Canada depends on the region. Over the low- and mid- troposphere there is a dipole of geopotential height anomalies, with a positive anomaly pattern associated with Azores high and a negative anomaly pattern centered over Hudson Bay during the low NAO period. Another dipole exists along the west coast of the North America. The characteristics of the dipoles indicate that the longitudinal pressure gradients over the mid- and high- latitude east coast of North America are strengthened, leading to intensified westerlies and wet summers on the east and west coasts of North America. During the high NAO index period along the east and west coast of the North America there are two dipoles out of phase with that during low NAO index, which suggest the longitudinal pressure gradients are weakened, leading to weakened westerly and dry summers in the east and west North America. The dipole of the atmospheric circulation over the low- and mid- troposphere along the east coast of North America is significant, which may influence the thermohaline circulation in the Labrador Sea. An elementary study of freshwater discharge from Canada also indicates the characteristics of decadal variability.

1-B-1.5

Interhemispheric Atmospheric Mass Exchange Associated with the Onset of an Active Phase of the Autralian Summer Monsoon

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In this study we examine an event where the northern hemisphere undergoes a loss of 1.80 hPa of hemispherically averaged dry air surface pressure over a 9 day period commencing on 3 March 1989. Similar to a 25 case composite of northern hemisphere cold season dry atmospheric mass fall events over a 30 year period from 1968 to 1997, this event is accompanied by a rapid buildup of the Siberian high and a subsequent pressure surge over Southeast Asia. Using the European Centre for Medium Range Weather Forecasts reanalysis and daily outgoing longwave radiation (OLR) data, we show that the northeasterly flow resulting from the pressure surge crosses the equator in

a broad zone extending from 100 deg E to 130 deg E. Longitude-time plots of OLR document a significant enhancement of convection within the monsoon trough of northern Australia commencing 7 March. The intense convection initiates only after the low-level northerly surge winds cross the equator and converge with the southeasterly winds from a southerly surge off the west coast of Australia. The vertical structure of the zonal winds within the monsoon trough depict the initiation of an active phase of the Australian Summer Monsoon (ASM). A deep layer of westerly winds extends from the surface to 400 hPa overlain by easterly winds. Within the subtropics of the southern hemisphere (~10 deg S) the low-level westerly wind burst occurs in response to the intensified zonal pressure gradient resulting from the atmospheric mass buildup in the region of convergence between the two hemispheric surges. We show that the diabatic heating anomalies associated with this onset of an active phase of the ASM act to redistribute dry atmospheric mass in the upper tropospheric divergent outflow. Three prominent anticyclonic circulations, stretching from the South Indian Ocean eastwards to the South Pacific, intensify beneath regions of upper tropospheric dry atmospheric mass convergence, originating from the monsoon convection outflow. These anticyclonic circulations are largely responsible for the dry atmospheric mass increase in the southern hemisphere.

1-B-2.1

Carbon Sinks in Seasonally Ice-Covered Seas: Physics and Biogeochemistry

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[2]*James J. Howard Marine Sciences Laboratory, Highlands, New Jersey, USA*
[3]*Department of Marine Sciences, University of Georgia, Athens, Georgia, USA*

Both the central Greenland Sea and the North Water area of northern Baffin Bay appear to be net annual sinks of atmospheric CO2, based on seasonal studies in both areas during the last decade. However, the sinks in these two contrasting (deep open ocean versus shallow coastal) areas result from very different interactions between the physical and biological regimes in each region. In the Greenland Sea, net biological export is severely limited by extremely deep winter mixing which brings remineralized carbon from intermediate depths back to the surface. However, the surface waters remain undersaturated in CO2 throughout the entire year, nonetheless, because of cold temperatures and associated deep convection. In contrast, the surface waters of the North Water do become supersaturated in CO2 during the winter, but heavy ice cover appears to prevent efficient outgassing to the atmosphere. Spring blooms of ice algae reduce surface CO2 to undersaturated levels by the time the ice clears, and the surface waters then remain undersaturated until ice begins to form again in the fall. Therefore, the North water is also a net atmospheric CO2 sink, if ice cover prevents outgassing from supersaturated surface waters throughout the winter. The different processes controlling air-sea CO2 exchange in the Greenland Sea and the North Water emphasize that the polar CO2 sink's response to climate change is unlikely to be uniform.

1-B-2.2

Physical and Biological Impacts of Early Spring Melt on the First-Year Ice Environment of the Canadian Arctic Archipelago

Martin Fortier[1], David Barber[1], Louis Fortier[2], Tim Papakyryakou,[1] and John Hanesiak[1]
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[2]*GIROQ, Département de biologie, Université Laval, Québec, Québec, Canada*

One of the first steps in understanding the impact of future climate variability on polar marine ecosystems is to better appreciate the current variability in forcing conditions that affect the primary production cycles at these high latitudes. Since the early 1990s, researchers from the Center for Earth Observation Sciences (CEOS, U. of Manitoba), the Institute for Space and Terrestrial Science (ISTS, U. of Waterloo) and the Groupe Interuniversitaire de Recherches Océanographiques du Québec (GIROQ, U. Laval, McGill, UQAR) have been conducting major sampling programs on the first-year ice of Barrow Strait, Canadian Arctic Archipelago. While the CEOS/ISTS programs focused on measurements of the seasonal evolution of the surface energy balance, snow & sea ice physical properties and remote sensing applications, the GIROQ program focused on the seasonal evolution of physical characteristics and biological productivity/export at the base of the ice cover and in the underlying water column. Large interannual variability recorded in the timing of melt onset were reflected in the response of the epontic and planktonic primary production cycles before the ice break-up. The earliest and most sudden melt event occurred in the spring of 1994, when record high air temperatures in May coincided with the earliest rain-on-snow event on record (1950-2001). By merging the data collected by both teams during this anomalous year, we present the detailed cascade of physical and biological responses of the snow- sea-ice -surface ocean system to sudden and early spring melt onset. In the light of warming scenarios predicted by GCMs, we discuss the potential impact of rain-on-snow and early spring melt on the

production seasons of the first-year sea-ice environment of the Canadian Arctic Archipelago.

1-B-2.3

Linking mesoscale and marine production in the Gulf of St. Lawrence : High-resolution 3-D ecosystem-circulation coupled model

Vincent Le Fouest[1]; Bruno Zakardjian[1], François J. Saucier[2] and Michel Starr[2]
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[2]*Institut Maurice-Lamontagne, Pêches et Océans Canada, Mont-Joli, Québec, Canada*

Expected climatic changes in response to increasing greenhouse gases concentrations will modify oceanic surface circulation and environmental conditions and, consequently, the related planktonic production, especially in high-latitudes. Spatial and time scales at which these direct interactions are most important extend from local to mesoscale because of the overlapping of physical and biological processes-related time scales. A better understanding of those biological-physical linkages is then needed to increase our ability to evaluate climatic forcing on oceanic production. We developed a 3-D biological-physical model to evaluate the role of mesoscale variability in plankton dynamics in the Lower Estuary and Gulf of St. Lawrence (Canada). The coupled model is driven by a 3-D high resolution primitive equations ice-ocean model and is focused on the competition between the herbivorous diatom-copepod food chain and the microbial food web which are characteristic of bloom and post-bloom conditions, respectively, as generally observed in temperate and subarctic seas. Preliminary results of the coupled model highlight the strong influence of mesoscale variability on phytoplankton distribution and daily production during the spring bloom in the Gulf of St. Lawrence

1-B-2.4

GEOHAB: a new international program on the ecology and oceanography of harmful algal blooms

Suzanne Roy
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A new international science program on the ecology and oceanography of harmful algal blooms (HABs) was developed in 1998 through the partnership of SCOR (Scientific Committee on Oceanic Research) and IOC (Intergovernmental Oceanographic Commission). The science plan is composed of five major themes: Biodiversity and Biogeography, Nutrients and Eutrophication, Adaptive Strategies, Comparative Ecosystems, and Observation, Modelling and Prediction. This talk will present an overview of this program and explain the need for such research activities. It will also discuss briefly Canada's future participation in GEOHAB.

1-B-3.1

Current status and future improvements in the Canadian Meteorological Center's analysis and forecasting system

Statut actuel et améliorations futures au système d'analyse et de prévision du Centre Météorologique Canadien

Richard Hogue and Yves Pelletier

Centre Météorologique Canadien, Dorval, Québec, Canada

The Operations Branch of the Canadian Meteorological Center (CMC) is responsible for running in the operational context the models and analysis systems that have been developed by the R&D Divisions of CMC and Meteorological Research Branch (MRB). The current status of the operational systems will be reviewed along with recent improvements. The implementation of the ISBA surface scheme in the regional GEM model in September 2001 as well as major improvements to the data assimilation cycle in both global and regional systems in December 2001 have improved notably the quality of the model forecasts. Main improvements planned over the next year will be briefly presented. The availability of CMC operational products (charts, images, bulletins, GRIB, BUFR, etc) will be reviewed with an emphasis on the planned work to implement a larger and more open access to the model data in GRIB format using FTP access on our public servers. As well, GEM model data in GRIB is now available on the UNIDATA system which is managed by UCAR and aims to give access to real-time meteorological data to the academic community for education and research purposes. Finally, our use of digital Canadian and US radar data will be presented.

1-B-3.2

Subgrid-Scale Orographic Blocking in the GEM Model

Ayrton Zadra, Michel Roch, and Stephane Laroche

Numerical Prediction Research Division Meteorological, Research Branch Environment Canada, Dorval, Quebec, Canada

A physical parametrization called "orographic blocking" is presented. It is based on a formulation by Lott and Miller (1997) and represents the drag on low-level winds that are blocked at the flanks of unresolved mountains in the GEM model. The blocking term plus the gravity-wave drag are now part of a unified parametrization of the subgrid-scale orographic drag which became operational on December 11, 2001. Details on the blocking scheme are given, as well as a description of its impact on meteorological fields. Results from tests with the various configurations of the GEM model are shown, illustrating how the blocking parametrization improves both the short- and medium-range forecast, especially in winter.

1-B-3.3

Recent improvements in the Canadian Meteorological Centre Unified 3D-var system

Clément Chouinard[1], Gilles Verner[2], Jacques Hallé[2], Cécilien Charette[1], Réal Sarrazin[2], and Bruce Brasnett[2]

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[2]*Data assimilation and quality control Division, Dorval, Québec, Canada*

The Canadian Meteorological Centre (CMC) 3D-var is an incremental analysis system, and is currently used by both our global and regional models with very little modifications. During the last few years, it has undergone a series of upgrades from isobaric to a terrain-following coordinate, to the direct assimilation of satellite radiances and recently, the use of temperature and surface pressure data from various sources,

namely radiosondes, synoptic stations and aircraft data. This has replaced our current use of geopotential heights as the main source of mass data. The quality control was also upgraded to a combination background check and variational quality control (QC). In terms of satellite data, the system now uses so-called raw level-1b AMSU-A radiances that are QC, and bias controlled at the user end. More recently, three lower peaking channels were introduced, bringing the total to 8 channels over water and 5 over the continents. The QC and thinning algorithms of these channels are more delicate, but their impact on analyses and forecasts are very large. The improvements in the quality of the global 10-day forecasts are very significant in all seasons, including a remarkable improvement in the QPF forecasts (3D Quantity of Precipitation Forecast). This is a clear indication of the better quality of the temperature and moisture analyses. The improvements in the regional system are relatively smaller but also indicate improved QPF and low level temperature and moisture forecasts.

1-B-3.4

Operational Implementation of the ISBA Surface Scheme in the Canadian Regional Weather Forecast Model

Stéphane Bélair[1], Louis-Philippe Crevier[2], Jocelyn Mailhot[1], Bernard Bilodeau[1], Yves Delage[2], and Louis Lefaivre[2]

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[2]*Canadian Meteorological Centre, Meteorological Service of Canada, Dorval, Quebec, Canada*

The summertime improvement resulting from the operational implementation of a new surface modeling and assimilation strategy into the Canadian regional weather forecasting system will be described at the conference. The surface processes over land are evaluated in this system using the ISBA landsurface scheme. Surface variables, including soil moisture, are initialized using a sequential assimilation technique in which model errors on low-level air temperature and relative humidity are used to determine innovations on surface variables. Results obtained with the new system show that the magnitude and nature of the corrections applied to the surface variables depend on the surface and meteorological conditions observed in each region. Also, objective evaluation against observations from radiosondes and surface stations indicate that the amplitude of the diurnal cycle of near-surface air temperature and humidity is larger with the new surface system, in better agreement with observations. This type of improvement was found to extend higher-up in the boundary layer (up to 700 hPa) where cold and humid biases were significantly reduced by introducing the new surface system. The model precipitation was also found to be significantly influenced by the new representation of surface fluxes.

1-B-3.5

Comparaisons entre les performances des modèles de prévisions des grands centres

Comparison of model performances for leading NWP Centres

Monique Loiselle et Tom Robinson

Canadian Meteorological Centre, Meteorological Service of Canada, Dorval, Quebec, Canada

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

résultats de vérification sera présenté. On examinera les vérifications contre analyses (chaque centre vérifiant contre sa propre analyse) pour les champs de pression au niveau de la mer, de hauteur, de température et de vent. On examinera aussi les vérifications contre observations (radiosondes) pour les champs de hauteur, de température et de vent. Ces comparaisons incluront les résultats du Canada (CMC), du Centre européen pour les prévisions météorologiques à moyen terme (CEPMMT), des États-Unis (NCEP), du Royaume-Uni (UKMetO), de l'Allemagne (DWD), du Japon (JMA) et de la France (Météo-France) pour les prévisions de 24 à 240 heures.

NWP model verifications are computed and exchanged monthly by many of the world's leading Centres. These verifications are prepared according to strict standards from WMO`s Commission for Basic Systems . A sample of verification results will be presented here, including verification against analyses (each centre using its own analyses) for MSL pressure, height, temperature and wind fields. We will also look into verification against observations (radiosondes) for height, temperature and wind fields. This comparison will include results from Canada (CMC), ECMWF, United States (NCEP), United Kingdom (UKMetO), Germany (DWD), and France (Météo-France) for 24 to 240-hour forecasts.

1-B-4.1

Ten years of Regional Climate Modelling in Canada: From the origins to where we stand.

René Laprise

Centre canadien de modélisation régionale du climat, Université du Québec à Montréal, Montréal, Québec, Canada

Due to the computational cost of Global Climate Models (GCM) -- whose cost increases roughly as the fourth power of the linear horizontal resolution -- and due to the length of climate simulations (several decades), GCM cannot access spatial scales that are required for climate-impact studies. A major objective for nested Regional Climate Models (RCM) is to produce climate-change projections on finer scales, consistently with the large-scale circulation of GCM. The Canadian Centre for Regional Climate Modelling (CCRCM) at UQÀM has worked on the development and the application of the Canadian Regional Climate Model over the past decade. The mandate of the CCRCM has been to develop a Canadian expertise in this novel research area of regional climate modelling, and to build, maintain, validate and apply a state-of-the-art simulator of regional climate. The CCRCM aims at carrying a set of interrelated scientific research projects in regional climate modelling and analysis to further the understanding of the physical processes taking place at the regional scale in the climate system. To achieve this goal and to secure scientific expertise in atmospheric and oceanic numerical modelling, climate analysis, diagnostic and statistical studies, Arctic climate and surface hydrology, the CCRCM has operated as a Network including the participation of several universities, the Meteorological Service of Canada and the Department of Fisheries and Ocean. The presentation will review the progress to date and present an overview of the themes under current investigation: diagnostic and budget studies, protocols for the validation of regional climate models, and improvements to the Canadian RCM.

1-B-4.2

Arctic climate simulations on the basis of global and regional models

Klaus Dethloff, Annette Rinke, Wolfgang Dorn, and Doerthe Handorf

Alfred Wegener Institute for Polar and Marine Research, Potsdam, Brandenburg, Germany

The climate is mainly determined by the spatial structure of large-scale atmospheric circulation patterns and their associated temporal changes. Internally generated climate variability on decadal to centennial time scales has been studied with a hierarchy of climate models, including global as well as regional models. Long-term model integrations of up to 1000 years with global models of different complexity have been analysed in order to find out whether the different models are able to simulate similar atmospheric regimes as the real atmosphere. The structure and variability of the modelled regimes of the atmospheric circulation, particularly the changes in the frequency of their occurrence, will be discussed. A regional model has been applied for simulations of the Arctic climate, because the Arctic is a region in which the sensitivity to changes in external forcings is very high, and in which future climate changes are likely to be largest throughout the world. By the use of the regional model, Arctic climate changes associated with large-scale atmospheric circulation changes have been studied in detail. It will be shown that a predominantly warm or cold Arctic winter climate is connected with two different circulation regimes of the Arctic atmosphere. The North Atlantic Oscillation (NAO) mainly affects the Arctic climate over the Atlantic-European sector and over Greenland. The magnitudes of the NAO related regional climate variations will be discussed in terms of their potential for the interpretation of palaeo-climatic data.

1-B-4.3

A numerical study using the Canadian Regional Climate Model over the Baltic Sea region.

Virginie Lorant[1], Norm McFarlane[1], and René Laprise[2]

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[2]*Centre canadien de modélisation régionale du climat, Université du Québec à Montréal, Montréal, Québec, Canada*

The Canadian regional climate model (CRCM) has recently been used to carry out seasonal simulations over the Baltic Sea region. The version of the CRCM used includes the third-generation subgrid-scale physics parameterisations package of the Canadian GCM (AGCM3). For this study the CRCM domain is centered over the Baltic Sea and is forced at its lateral boundaries by data from the NCEP atmospheric reanalyses. Advantage is taken off the Baltic Sea experiment (BALTEX) observational data and regional model inter-comparison project to evaluate the CRCM behavior. The sensitivity of the simulated CRCM results to some aspects of the parameterisations of moist processes in CRCM/AGCM13 will be discussed.

1-C-1.1

Modelling the Sub-Polar Gyre of the North Atlantic Ocean

Paul G. Myers
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A regional scale model of the sub-polar North Atlantic (SPOM) has been developed to be used as a tool for studies of the ocean and ocean/climate interactions on decadal and longer time scales, with a planned focus on process and sensitivity studies. With the inclusion of an eddy parameterization and a representation of topography based on partial cells, the model is able to accurately simulate the large scale hydrography and circulation of the sub-polar gyre. Results are presented showing the importance of topography in controlling inflow into the Greenland-Norwegian Seas region, the formation locations of sub-polar mode water and circulation pathways in the Labrador Sea. An analysis is also performed examining the details of Labrador Sea Water dispersal in the model. Preliminary results will also examine the role that freshwater forcing in the Labrador Sea region has upon the circulation and water mass formation processes. The talk will also present an overview of the oceanography of the region as well as previous modelling work.

1-C-1.2

The Freshening of the sub polar North Atlantic

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The 1960s marked a zenith in large scale classical oceanography in the North Atlantic that wasn't to be repeated again until the WOCE intensive North Atlantic survey in 1995-1997. Comparing these two periods, shows that all the intermediate and deep waters have substantially freshened. This freshening is equivalent to the addition of 3.9 metres of freshwater averaged over the entire gyre. The freshening is greatest in the Labrador Sea Water within the Labrador and Irminger Seas, but substantial freshening is present in the deep waters and in much of the eastern basins. Using our own observations from the Labrador Sea and Newfoundland Basin as well as European data from the Irminger Sea and Iceland and Rockall basins, we will argue that make of this fresh water first entered the surface waters of the sub-polar gyre. The gyre circulation carried this water into the Labrador Sea where the intense winters of the early 90s incorporated it into the coldest, densest, freshest and deepest Labrador Sea Water yet observed. This Labrador Sea Water spread first to the Irminger Sea and then into the Iceland Basin where it became the dominant water mass being entrained into the Færœ – Shetland and Denmark Strait Overflow waters when they enter the North Atlantic from the Nordic Seas. While these overflows themselves are observed to be freshening, the freshening of the entrained waters sustains and enhances this freshening as these waters pass through the sub-polar gyre. Intense convection in the Labrador Sea ceased in 1994. Since that time this reservoir of cold, fresh and dense 1994 vintage Labrador Sea Water has slowly warmed, become more saline and a little less dense, first in the Labrador Sea, then in the Irminger Sea and more recently in the Iceland Basin. Examination of T and S time series over the past 53 years showed that the pattern of T and S variations noted in the LSW during the recent years were very similar to those observed in the 1950s and 1960s. However, the magnitudes of annual T and S changes associated with the build-up and decline of LSW in the 1990s are twice or more higher than the estimates for similar events in the 1950s and 1960s. The time series of the Northeast Atlantic Deep Water (NEADW) and Denmark Strait Overflow Water (DSOW) show rapid increases of T and S in the early

1960s with slow declines into the 1990s except for 5-year oscillations in the DSOW over the past 15 years. We will continue our annual surveys looking to see if this most recent behaviour is decadal variability or change.

1-C-1.3

An Eddy-Permitting Model of the North Atlantic With Assimilation of Long-Term Hydrographic Information

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The Parallel Ocean Program with a 1/3rd degree horizontal grid is used to illustrate the utility of frequency-dependent nudging in an eddy-permitting model of the North Atlantic. Standard diagnostic and prognostic results are used to illustrate both the strengths and the weaknesses of these approaches. A new approach is then described that can be used to prevent model drift away from observed climatological conditions without suppressing variability about these conditions. The method allows one to restore model results towards the corresponding climatological results for just those frequency bands where this is desirable. We illustrate the approach using a model of the North Atlantic. The mean and seasonal cycle of the temperature and salinity differences between the model and observations are estimated using an efficient sequential approach (based on the Kalman filter) and the long-term mean misfit is then nudged towards zero. Knowledge of both the mean and seasonal cycle of the misfit are used to impose simple restoring surface boundary conditions that do not strongly suppress variability about the seasonal cycle. This approach reduces the unrealistic feedback between surface salinity anomalies and the surface freshwater flux that results when standard restoring boundary conditions are used. We show that the nudging maintains realistic mean conditions for water mass properties, sea level, barotropic and overturning stream functions and meridional heat flux. The seasonal cycle in mixed layer conditions, which is not controlled by the nudging, is also realistic and eddy variability is significantly improved in comparison to the results from the prognostic model. Our results demonstrate the importance of having good estimates of climatological conditions and prospects for improvements are discussed. Possible extensions and applications are also discussed.

1-C-1.4

Comparison of Diagnostic, Prognostic and Semi-Prognostic Methods in simulating Currents and Tracer Transports in the Northwest Atlantic

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A primitive equation ocean circulation model is used to study the seasonal circulation and major pathways of passive tracers in the Northwest Atlantic. The model is forced by monthly mean temperature and salinity, monthly mean COADS wind stress and heat flux, and flows through the model open boundaries. To improve the model performance in simulating circulation and passive tracers, the semi-prognostic method suggested by Sheng et al. (2001) is used in this study. The novel aspect of this method is that the model currents are adjusted toward climatology, while the model temperature and salinity equations are fully prognostic. For direct comparisons, the pure-diagnostic and pure-prognostic methods are also used in this study. In diagnostic calculations ocean currents and tracer equations are calculated with temperature and salinity specified at all model grid points at each time step. In prognostic calculations, by contrast, the

temperature and salinity equations are integrated forward along with the momentum and tracer equations. The ocean circulation model is integrated for five years with two sets of passive tracers seeded in the Labrador Sea. Multi-year model results reveal that the semi-prognostic method performs significantly better than the pure-diagnostic and pure-prognostic methods in simulating circulation and major pathways of passive tracers in the study region.

Sheng, J., R. J. Greatbatch, and D. G. Wright, Improving the utility of ocean circulation models through adjustment of the momentum balance, J. Geophys. Res., 106, 16711-16728, 2001.

1-C-2.1

Introduction of Variable Drag Coefficients into Sea-Ice Models

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In order to consider the effect of different ice conditions on the momentum exchange between atmosphere and ocean a parameterization for variable drag coefficients is introduced. A square dependence on ice concentration is combined with a linear dependence on deformation energy to account for the influence of floe edges as well as for roughness elements in regions with a more compact ice cover. Deformation energy has been introduced as a prognostic variable, expressing accumulated work performed on the ice cover. The approach is not regionally specified and is applied over the whole model region. The application leads to temporally and spatially varying drag coefficient ratios, affecting ice drift as well as ice deformation. The parameterization has been tested in a sea-ice only model, where empirical parameters are optimized via comparison with observed buoy drift data, and is now implemented into a coupled sea-ice ocean model.

1-C-2.2

Re-distribution of sea-ice thickness through ridging: Measurements and models.

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To better estimate how changes in global climate will provoke a differing draft distribution of sea ice in the Arctic, we need to understand how the ridges and level ice that characterize the ice pack are created and maintained. Current ice re-distribution models which account for thermal and mechanical processes reproduce the observed ice thickness distributions, yet they are generally used to model the entire Arctic Basin on annual timescales, such that they produce average draft distributions rather than responses to individual forcing events on timescales of weeks and length scales of kilometres. To calibrate these models with experimental data, this study adapts existing ice re-distribution models to look at sea ice development in the coastal regions of the Beaufort Sea. Analysis in this area introduces constraints not present in large-scale Arctic models. The Beaufort Sea is an excellent experimental site for such a study, as new ice is formed throughout the winter in large leads, which provides constant input of thin ice available for mechanical ridging. Extensive draft data from moorings spanning 11 years has been collected in the Beaufort Sea and provide data for both model initial conditions and validation. The re-distribution model is designed to allow mini-modelling experiments where the impacts of observed mechanical and climate conditions on the initial ice distribution are predicted through a parameterization of the processes involved. Agreement of model predictions with observed draft distributions suggests that the processes are correctly represented. Applications of this meso-scale re-distribution model to the Beaufort Sea winter ridge formation provides modelled draft distributions in agreement with the observed conditions, suggesting that accurate predictions of sea ice ridging under varying climatic conditions are possible in coastal areas.

1-C-2.3

Sea-Ice Simulations Using a Coupled One-Dimensional Thermodynamic Snow Sea-Ice Model

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Most models of sea ice represent the snow layer as a single bulk layer with simple physical and thermal properties. A detailed one-dimensional mass and energy balance snow model (SNTHERM) has recently been adapted to a multi-year sea-ice surface but does not allow the ice layer to ablate or accrete over time. This paper will discuss some results of a coupled snow sea-ice model that accounts for most detailed snow processes as well as allowing the ice layer to ablate and accrete over an annual basis. The coupled model is comprised of SNTHERM for snow processes and the Flato and Brown (1996) seasonal (first-year) sea ice model. The coupled model is capable of simulating multi-year and first-year sea-ice scenarios with acceptable accuracy when forced with in-situ data. Examples of model versus observation comparisons over multi-year and first-year sea ice will be given using data collected from the SHEBA (Surface Heat Budget of the Arctic ocean) project and C-ICE (Collaborative-Interdisciplinary Cryospheric Experiment). Particular emphasis will be placed on the spring melt period.

Flato, G.M. and R.D. Brown, 1996: Variability and climate sensitivity of landfast Arctic sea ice, J. Geophys. Res., 101(C10), 25767-25777

1-C-2.4

Regionality of Hudson Bay sea-ice thickness

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Seasonal sea ice in Hudson Bay plays a key role in determining the regional climatology. The relationship between sea-ice thickness and local surface air temperature is explored. A high correlation was found with basin averaged sea-ice thickness and concurrent surface air temperature, consistent with previously published results. However, local sea-ice thickness did not correlate well with local temperature data. A regional analysis indicates that when dividing the region first into eastern and western sections and then into northern and southern sections, high and significant correlations occurred for southern and eastern sections for both winter and summer surface temperatures. Multiple regression analysis indicates summer temperatures play the dominate role for the southern and eastern regions. The lower correlations for sea-ice growth and winter temperature illustrates the insulating nature of sea ice itself once it has formed. A conceptual model linking sea ice, summer and winter surface air temperatures and the prevailing wind is proposed. This has important implications for the modelling of sea ice in the Hudson Bay region.

1-C-2.5

Coupled Ice-Ocean Model Study on the Northwest Atlantic Ocean

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The Los Alamos Sea Ice Model is coupled to a northwest Atlantic ocean circulation model to simulate ocean currents and seasonal sea ice advance and retreat over the Labrador and Newfoundland Shelves. This newly developed coupled ocean-ice model differs from

other coupled ocean-ice models developed for the region mainly in two ways. First, the semi-diagnostic method suggested by Sheng et al. (JGR, 2001) is used in the ocean circulation model to reduce the model drift in the multi-year simulation. Second, Winton's 2.5 layer thermodynamics is use in the sea ice model to include the heat capacity of the sea ice and the brine pocket. In comparison with the observations in the region, we found that the new coupled ocean-ice model reproduces reasonably well the annual cycle of the sea ice in the region. In particular, the inclusion of the heat capacity of the ice reduces significantly the excessive spring time melting, which is a common problem shared by all of the earlier studies.

1-C-3.1

Modélisation du cycle atmosphérique du mercure et transport sur l'Arctique

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L'étude des écosystèmes arctique et subarctique révèle la présence anormalement élevée de certains contaminants persistants tel que le mercure. Ce métal lourd peut séjourner plus d'un an dans l'atmosphère, étant chimiquement très peu réactif sous sa forme dominante. La plus grande part du mercure atmosphérique est sous forme élémentaire, relativement volatile et peu soluble. Son temps de séjour prolongé permet son transport à l'échelle globale, de sorte que l'environnement arctique se trouve affecté par les émissions de mercure en provenance des grands pôles industriels. Seule l'utilisation de modèles globaux permet d'évaluer cet aspect de la pollution atmosphérique par le mercure. Au Service Météorologique du Canada, le modèle GRAHM (Global/Regional Atmospheric Heavy Metals) a été développé spécifiquement pour simuler la circulation atmosphérique du mercure. Il bénéficie en son cœur du modèle GEM (Global Environnemental Multi-échelle) du Centre météorologique canadien, auquel ont été greffés les processus physico-chimiques associés au mercure. Quatre variétés sont représentées (Hg0, HgCl2, Hg(p) et HgO), ainsi que leurs réactions en phase aqueuse et gazeuse, la sédimentation en fonction de la surface, la diffusion dans la couche limite, un schéma détaillé d'interaction avec les nuages et le dépôt humide. Les émissions naturelles et anthropiques sont simulées. Le modèle est présentement utilisé afin d'évaluer les principaux patrons de circulation globale du mercure et son temps de séjour moyen. Il permet aussi de dresser des bilans atmosphériques globaux et régionaux. Nos récents résultats permettent d'éclaircir en partie la question de l'origine de la pollution polaire par le mercure.

1-C-3.2

Relationship Between DMS Ventilation and Ocean DMS Pool Viewed in a Coupled Biogeochemical-Ocean Model

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Dimethylsulfide (DMS) is a climatically-active gas produced by oceanic plankton. Its ventilation to the atmosphere constitutes the major natural source of reduced sulfur in the marine environment. Sea-to-air flux of DMS depends on wind strength, sea surface temperature, and on the availability of DMS in the ocean surface layer. Current coupled ocean-atmosphere models use constant DMS concentrations, which does not take into account rapid changes in the DMS pool. To investigate the relationship between wind, DMS ventilation rate and the ocean mixed layer DMS reservoir, we performed short sensitivity experiments with a 1-D coupled biogeochemical-ocean model. The model includes a DMS production module with 6 biological compartments (NODEM; Northern Ocean DMS Emission Model) and a state-of-the-art ocean turbulent model (GOTM; General Ocean Turbulent Model). Simulations with theoretical wind scenarios allow us to evaluate the temporal evolution of ocean surface DMS levels and sea-to-air fluxes in the North West Atlantic. The role of wind-induced turbulence on the deepening of the mixed layer and on the replenishment of the subsurface water in DMS is investigated. The impact of the currently used gas transfer models is also tested. The ability of biological processes to replenish the DMS pool after wind events will be discussed.

1-C-3.3

Productivity and dissolution of biogenic carbonate and planktonic foraminifera in the north northwestern Pacific: response to climatic variability of the Northern Environment

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Productivity of biogenic components and variation of planktonic foraminiferal fluxes were observed through sediment trap experiments at several stations in the north northwestern Pacific Basin reveal the seasonality, interannual and depth variability of total particulate, biogenic components and planktonic foraminiferal fluxes of the northern environment. Results from five traps sites were presented in this study as a part of long time sedimentation and carbonate dissolution observation program using an array of traps at different depths. The experiment were conducted in order to understand the characteristics of settling particles related to biological pump and local hydrography as the marine biochemical processes may play an important role in regulating the atmospheric concentration of CO2, mediate through air sea exchange. The relationship between total calcium carbonate and foraminiferal fluxes in different water column at these stations were also investigated to evaluate the productivity of biogenic carbonate, contribution of foraminiferal calcite to the total carbonate flux and differential dissolution on particulate shells. Observation of vertical variation of foraminiferal calcite particles at the present stations may have intimate relation with the shallow carbonate compensation depth of the northern environment resulting decrease the particulate calcium carbonate flux with increasing depth. Moreover, observed decrease in foraminiferal flux with depth at these stations may be attributed to dissolution within the traps in addition to the loss of smaller foraminifera to dissolution during settling. The foraminiferal carbonate that reaches the seafloor accounts for an average 20-27 % of the total carbonate in this region. The seasonal variation in biogenic particulate fluxes in the northern Pacific Basin implies that temporal changes in biological productivity are governed by large-scale seasonal climatic variability and local hydrography. Seasonal distribution of foraminiferal species fluxes as well as other biogenic particulate fluxes will be discussed in terms of ocean parameters in the northern environment for paleoceanographic interpretation.

1-C-3.4

A Two Compartment Model for Biodegradation in Porous Media

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In situ bioremediation is a technology that is currently being studied in the hope that it may be useful in remediating the nation's hazardous waste sites. However, the rate and degree of microbial degradation are controlled by a number of biotic and abiotic factors among which sorption is of great importance. Sorption can either enhance or decrease microbial degradation rates depending on the partitioning of both microorganisms and organic substances between the solid surfaces and the pore water. In this work, we study

the mineralization of phenol as a substrate polluant by a pseudomonas bacteria . Our system is a column of the soil in which we show how diffusion and adsorption control the rate of biodegradation. We find that the Monod kinetics doesn't describe the rate of biodegradation of the substrat in our system. A two- compartment model is then developed to predict the rate of substrate subject to biodegradation. The model suppose that the substrate can be present in two forms, like in solution where it is transformed or sorbed to a surface where it may be unavailable for microbial use. After the supply of substrate in the first compartment is depleted, the subsequent rate of biodegradation would be governed by the rate of desorption or diffusion of the substrate from the inaccessible micropores to sites containing the active microorganisms.

1-C-3.5

Estimating Weathering Rates in Boreal Forested Environments: Effects of Climate on Grain-Size and Mineralogy Distributions in Lac Clair Watershed, Duschenay Forested Station (Quebec)

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Soil weathering is an important source of nutrient cations for development of forested ecosystems, but the release rates of these nutrients are not well known. Weathering rates also influence soil buffering capacities related to acidic deposition in watersheds and control the cycling of many inorganic nutrients which are important in soil fertility and on long term climate change. It is known that the climate exerts an important influence on chemical weathering (White & Blum, 1995). Climate affects the weathering rates by the parameters as temperature and the humidity in the air and especially in the soil horizons but the quantification of these processes is not established yet. Soil can be defined as a natural body consisting of generally inconsolidated layers or horizons of mineral and/or organic constituents of variable thickness which differ from parent material in morphological, physical, chemical and mineralogical properties. Jenny (1980) proposed any dependant soil property as a function of a number of independent soil properties such as parent material, topography, age, climate, and organisms. Weathering rates of primary and secondary minerals in the soil are strongly influenced by specific soil environments. The rate of release of base cations which are necessary for the plant growth will be governed by the mineralogical composition and the particle-size of grains in each horizon of the soil sequences that are function of the soil environment. We investigate the soils from the Lac Clair Watershed (46 degrees 17' N, 71 degrees 40' W) in Duschenay forested Station near Quebec City located along a climate-vegetation on the Canadian Shield. The vegetation is a typical northern hardwood forest of north-eastern North America. The objectives of this study are (i) to simulate by the Local Climate Model the atmospheric parameters resulting from the land-atmosphere exchanges and particulary to establish the variations of the temperature and the humidity rates in the upper layers (4 upper meters) of soils by the CLASS Model included in the LCM (Verseghy et al., 1993), (ii) to review the development of soil mineralogy and particle-size classes related to climatic conditions, (iii) discuss certain problems associated with current mineralogy classes and the characterization of soils mineralogy by the mineralogical composition of a selected size fraction, (iv) propose a framework for evaluating the weathering rates based on the mineralogical composition, the grain-size control and the mineral evolution in the soils horizons in specific environments. For this study, we assume that the composition of the parent materials is represented by that of the basal C horizon. Major minerals in the regolith are quartz, feldspaths, micas, argilleous minerals (chlorite, kaolinite, interstratified minerals,...) and iron oxides (goethite, ilmenite, hematite and magnetite,...). The relative abundances of these

minerals and their texture broadly reflect variations in primary mineralogy related to different lithologies and alteration in different horizons. In process of the weathering rates evaluation, we will learn more about the distribution of soils minerals and their grain-size, how minerals occur in certain environments, their transformations, how they are affected by specific soil management practices and uses under given climatic conditions, and the ultimate prediction of future soil behavior in forested environments.

Jenny H., 1980, Factors of Soil Formation. McGraw-Hill, New York, 329 p.

Verseghy D.L., N.A. McFarlane and M.Lazare, 1993, CLASS-A Canadian Land Surface Scheme for GCMS.II. Vegetation Model and Coupled Runs, Intern. J. Clim. 13: 347-370

White A.F. and A.E. Blum, 1995, Effects of Climate on Chemical Weathering in Watersheds. Geochim. & Cosmochim. Acta 59: 1729-1748

1-C-4.1

The new version of the Canadian operational GEM regional mesoscale model: An overview

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A new mesoscale version of the GEM regional model in operation in Canada for numerical weather prediction has been under development for some time. The main changes to the modeling system include an increased resolution both in the horizontal (on the order of 15 km instead of 24 km) and the vertical (43 levels instead of 28) and improvements to almost every aspects of the physics package. These include a new surface processes package (with a mosaic-type treatment of land surface over continents - ISBA scheme with vegetation and snow -, open waters, sea ice, and glaciers), an improved formulation of the boundary layer to represent clouds with an unified moist turbulence approach, the Kain-Fritsch deep convection scheme, and the Tremblay mixed-phase condensation scheme with explicit microphysics, together with revisions to the cloud radiative optical properties. The effect of low-level blocking due to subgrid-scale orography based on the Lott-Miller scheme has also been included. The new surface modeling system uses a high-resolution dataset to generate the geophysical fields (vegetation types, soil properties,...) and a sequential assimilation method has been developed for surface and soil variables (soil tempearture and soil moisture). An overview of the various aspects of the new mesoscale modeling system will be presented at the Congress.

1-C-4.2

The new version of the Canadian operational GEM regional mesoscale model: Some preliminary results

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The Canadian Meteorological Centre (CMC) is in the process of testing and evaluating a new version of the regional model with a resolution of 15 km. In order to implement a new model, one must not just change the horizontal and vertical resolutions, but also adjust the different physical parameterizations to this new resolution. As will be described in the companion paper (Mailhot et al), several changes are also proposed to the physics package that will affect the behaviour of the new model. Numerous test cases were launched in both summer and winter atmospheric conditions to verify the advantages of the proposed version over the operational one. The talk will exemplify the advantages of the proposed version using a few case studies, but will also show objective verifications of the new system. These verifications will be comparable to the operational environment, as they will include regional 3-D analyses and surface spin-up so that the soil humidity from ISBA (as described in Belair et al) is in equilibrium with this new forecast system.

1-C-4.3

The relative contributions of data sources and forcing components to the large-scale forecast accuracy of an operation model

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In the atmosphere, the majority of the kinetic energy lies in the low wave number part of the energy spectrum. Because of this, the solution of the diabatic three-dimensional equations can be decomposed into a large-scale and residual component. In turn, this can justify forecasting initially only the evolution of large-scale motions and then using those results as boundary conditions for limited area forecasts of developing smaller scale features. In this study, the relative contributions of some of the forcing components in an operational global weather prediction model are quantified in order to determine which are the major contributors to the large-scale forecast accuracy over time. This allows the complexity of the large-scale forcing to be chosen according to a preselected level of accuracy in the large-scale forecast. In a similar manner, the relative contributions of various observational data sources are quantified so that appropriate observational data sources can be chosen to satisfy the preselected level of accuracy.

1-C-4.4

A hybrid vertical coordinate for the GEM model of the CMC/MRB.

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A hybrid vertical coordinate, which is terrain-following at low levels but tends continuously to pressure surfaces at upper levels, has been introduced in the Global Environmental Multiscale (GEM) model. Results of 5-day forecasts using the operational GEM model with a top levelset to 1mb will be presented for the winter period of 1997. The encouraging results have motivated an implementation of the hybrid vertical coordinate in the new MPI version of GEM. An extensive validation of the new model coupled with a modified version of the 3DVar system with a top level set to 10mb has shown no substantial impact of the new vertical coordinate in the analysis cycles, except over mountains where the new hybrid formulation compares favorably to the operational one. Furthermore, an extended stratospheric version of the MPI version of the GEM model has been developed with 80 hybrid levels and a top level set to 0.1mb. A January model climate has been produced with this vertical configuration and will be compared to the means of the corresponding data from the NCEP re-analysis.

1-C-4.5

Evaluation of very high resolution GEM model over mountainous terrain

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The Pacific and Yukon Region (PYR) and the Canadian Meteorological Centre (CMC) have started a joint program in collaboration with the Meteorological Research Branch to evaluate the performance of a 2.5 km resolution model centred over southern British-Columbia (BC). This project is testing the viability of the higher resolution model as a replacement for the existing experimental HiMAP runs at CMC. The GEM model is used in its variable grid configuration with a uniform resolution that covers a very small domain. The physical parameters are also adapted to this resolution, where the convection scheme was deactivated and a more complete cloud microphyics scheme used. The option of running in non-hydrostatic mode is also possible. This set-up was already tested over other areas of Canada, but it is a first over mountainous area. Considerations of induced topographical effects will be examined during the presentation along with a few case studies and comparison with the regional model.

1-D-1.1

A New Climatology of the Labrador Sea

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The Labrador Sea is an important site for deep convection. The observed variability in its water masses has potential effects on the global scale Thermohaline Circulation. Therefore understanding the observed variability on different time scales is crucial in predicting regional and global climate change. Recently, inter-annual and -decadal variability in the water masses in the Labrador Sea has been studied extensively with the help of a growing number of observations. The Climate Database of Bedford Institute of Oceanography is one of the most extensive and up-to-date databases built for the North Atlantic Ocean. For this particular study, nearly a million separate temperature and salinity profiles were selected to investigate the region bounded by 45° to 70° North Latitudes and 40° to 75° West Longitudes. Our aim is to analyze the T-S data dating back to 1910 to derive the climatological mean state of the Labrador Sea, and to infer the three-dimensional current structure using a diagnostic model. For this purpose the T-S data are objectively analyzed onto a 1/3° by 1/3° grid. Initially the mapping is done in geopotential coordinates, with 44 vertical levels at fixed depths. The objective analysis scheme includes features to preserve strong frontal currents by searching for data along the isobaths over a depth range. This method minimizes the mixing of coastal waters with offshore waters and hence prevents the fronts from being smoothed over the topography. The second part of the analysis involves mapping the data using a more natural isopycnal coordinate system in the vertical. The results from the two aforementioned approaches will be discussed.

1-D-1.2

Variations in JEBAR due to Full and Partial-cell Topography Representation

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JEBAR describes important interactions between the depth-integrated flow and the ocean-bottom topography. These interactions can mathematically be portrayed as either a barotropic vorticity correction or an ocean-bottom induced tourque applied on the depth-integrated flow. The representation of topography is a key element in both descriptions. The accuracy of traditional z-level ocean general circulation models in representing JEBAR is limited by their use of "staircase topography". Recently a new topography representation for z-level ocean models has been developed. In this finite-volume technique the bottommost cells are partially filled so as to better approximate the ocean-bottom surface. It is expected that an ocean model utilizing partial-cell topography representation will produce more accurate and continuous JEBAR fields than a "full-cell" ocean model. Current research involves the investigation of JEBAR in the sub-polar gyre of the North Atlantic using an existing geopotential OGCM that can implement both full and partial-cell topographic representations. Field values are explicitly determined for the barotropic vorticity correction and bottom surface tourque descriptions of JEBAR. Dominant vorticity and tourque terms are identified for specific topographical features and geographical locations. Changes in the model momentum balance are also examined.

1-D-1.3

Water column structure and circulation under the North Water Polynya during spring transition: April-July, 1998

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The North Water is a large recurring polynya in northern Baffin Bay. Over 400 hydrographic CTD stations taken from this region between April and July 1998 were examined to better understand the water column structures underlying the polynya during spring transition. These data portray the North Water to be an area where imported and dissimilar water masses converge over a complex bathymetry. Arctic-derived inflows (termed 'northern assembly' waters, NA) and Atlantic-derived inflow (termed 'southern assembly' waters, SA) interleave and mix along isopycnal surfaces. NA waters are derived from inflows through Nares Strait and Jones Sound; SA waters are derived from a northern-moving branch of the West Greenland Current (WGC). The most important mixing site under the polynya was above the north-south setting Smith Sound Canyon, between 76.5 and 77 N latitude. Here, NA and SA waters advance and mix to form a distinct relatively thick halocline layer termed 'North Water assembly' (NWA) characterised by density-compensating thermohaline intrusions. Further south, a sharp front separating NWA waters from SA waters nearly 2 C warmer at depths between 200 and 400 m roughly aligns with the 500m isobath. Flow patterns deduced from correlations of potential temperature vs salinity, and from minima in stability frequency profiles indicate that this front is manifest by convergence associated with a branch of the WGC that is cyclonically redirected as it approaches Smith Sound Canyon. While potential temperature and salinity distributions show some evidence of upwelling along the Greenland coast, no surfacing of warm Atlantic-derived water was observed during the sampling period, suggesting that the North Water's opening is primarily a function of mechanical ice removal by winds and currents. Some sensible heat exchange associated with brine rejection and penetrative convection may occur, but only during periods of active ice formation.

1-D-1.4

Heat and salt budgets in the Scotian Slope Water recirculation gyre

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We use two years of data archived from a high resolution model run to derive temperature and salinity budgets for the Slope Water along the Scotian shelf. The model is the 1/10th degree version of the Parallel Ocean Program (Smith et al., 2000). The model solution has a very realistic Gulf Stream, Slope Water and Labrador Current. The volume of water under consideration is the Slope Water recirculation, bounded at the south by the Gulf Stream and at the north by the Scotian shelf. South of the Grand Banks, a small gap allows the inflow of the Labrador Current. We choose to examine the horizontal slice bounded by the 50 and 500m depths. Both the mean advection from the south (the Gulf Stream influence) and the eddy exchange across the Gulf Stream act to increase the temperature and salinity of the region (both being of equivalent magnitude). The mean advection from the east (the Labrador Current influence) and convection tend to decrease the temperature and salinity (both being of equivalent magnitude, roughly similar to the magnitude of the previous two terms).

1-D-1.5

Influence of wavy coastlines on wind-driven Munk circulation and the inertial runway problem

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We consider the single gyre Munk problem in a shallow water setting, and under free slip boundary conditions. It is well know that for rectangular geometries, solutions "run away" (develop unrealistically large velocities) as the viscous coefficient is lowered. For basins with curvilinear boundaries, there is some ambiguity as to how the free slip condition should be defined. For example, along a straight wall, free slip implies that all three of the vorticity, the normal derivative of tangential velocity and the normal flux of tangential momentum are all zero. Along a curved boundary, this is not generally the case. Here, we take free slip to imply zero normal derivative of tangential velocity at the wall. First, we consider a circular domain, and show that solutions there "run away" in a manner similar to the rectangular basin case. Next, we explore how the presence of a wavy coastline affects this result. We find that the presence of irregular walls retards the inertial runaway but their presence is insufficient to stop it.

1-D-1.6

Sea Surface Temperature in Canadian Atlantic Waters

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We present the results of an investigation of the 1981 to 2000 weekly composite Sea Surface Temperature (SST) provided by the Jet Propulsion Laboratory (JPL). A harmonic analysis has been performed on the time series to extract the mean, as well as the annual, semi-annual and tri-annual cycles of SST. The mean temperature field reveals features of the Labrador Current and upwelling in the northern Gulf of St. Lawrence and Estuary. The largest annual cycles are found over the continental shelf (e.g. SW Grand Banks) and within the Gulf of St. Lawrence, particularly over the Magdalen Shallows. Low values are present off the western Nova Scotia coast, in the Bay of Fundy and over Georges Bank. The harmonic analysis also reveals the tidally well-mixed area of SW Nova Scotia, the shelf-slope front, and the influence of slope water along the Scotian Shelf. On average, the sum of the mean and first three harmonics of SST can account for 82 % (96% in the southern Gulf) of the weekly sampled SST variance. A correlation analysis of SST anomalies (obtained by subtracting the reconstructed series from the observed series) establishes spatial scales of variability in the study area. The horizontal correlation scales, defined as the distance over which the correlation coefficient falls under 0.7, range from 30 km in the St. Lawrence Estuary, to 250 km over the Grand Banks. Auto-correlation analysis shows temporal scales generally lower than 20 days. The mean and harmonics SST signals, combined with a statistical prediction of the anomalies (neural network), would provide a nowcasting and forecasting system for SST in the area.

1-D-2.1

Global Warming in the Arctic: What about Northern Québec and Labrador?

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The predicted amplification of the effects of global warming at high latitudes makes it important to understand the potential response of the circumpolar region and its abundant freshwater ecosystems to global climate change. To explore the potential responses of northern lakes to climate change and to place instrumental temperature records into a longer-term perspective, we studied the fossil diatom, chironomid, pollen and macrofossil records preserved in the sediments of 15 lakes distributed throughout northern Québec and Labrador. Diatom stratigraphic sequences and diatom-inferred patterns of limnological change since basin formation following the retreat of ice sheets and post-glacial marine waters revealed Holocene lake trajectories that are closely associated with successional shifts in lake catchment vegetation and soils. The main trends observed in all reconstructed lake histories are: (1) a progressive loss of alkalinity over time; (2) abrupt increases in dissolved organic matter (DOC) and water colour that coincide with the arrival of conifer trees; and (3) subsequent shifts that are closely correlated with the export of organic matter to recipient lakes. In terms of paleoclimate, our chironomid-based reconstructions of surface water temperatures together with the diatom records provide evidence for relatively stable climatic conditions or slight cooling over recent centuries in eastern subarctic Canada, up until the present-day. This climatic scenario is in sharp contrast with records of climate warming as inferred from other paleolimnological studies conducted in northwestern Canada and Alaska, yet it is consistent with decadal observational data that reveal pronounced climatic cooling over the western subpolar North Atlantic and adjoining land areas of eastern Canada.

1-D-2.2

Multi-proxy temperature reconstruction during the Holocene in northern Sweden

Isabelle Larocque
Multi-proxy temperature reconstruction during the Holocene in northern Sweden
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A 100-lake training set has been developed in Lappland, northern Sweden. Of the 16 environmental and chemical variable studied, July air temperature was the most important variable explaining the distribution of both chionomids (non-biting midges) and diatoms. A calibration set was then developed and used to reconstruct July air temperature in three cores during the Holocene. The three chironomid reconstructions showed a decrease of about 2ºC through the Holocene. The same decrease was registered in two cores using diatom-inferred temperature reconstructions. In the third core, it seems that an ecotonal boundary was not reached for diatoms and masked the effect of temperature.

Absence of modern analogues in the early Holocene does not allow for a reliable temperature reconstruction at that time. Other factors, such as lake developments or nutrients, might be more important, masking the effect of temperature changes.

Validation of chironomid-inferred temperatures was obtained by comparing with instrumental data for the last century. A good correlation exist between chironomid-inferred temperature and meteorological data, showing that chironomids are good indicators of temperature for the last 100 years. This relationship should be proven on longer time scale, where we think that other factors might have been more important than temperature from time to time, explaining the divergence observed between diatom, pollen and chironomid-inferred temperature reconstructions.

1-D-2.3

6,000-year record of climate change in the Canadian Arctic: Quantitative reconstructions from dinoflagellate cysts

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Data from recent oceanographic experiments and historical records are needed to constrain GCMs that forecast future climate change in the Canadian Arctic. However, historical records cover less than 200 years, which is a small part of the natural warm-cold cyclicity known from geological records and inferred from archaeological evidence. For example, over the past 1 MA record, glacial-interglacial cycles show SST changes of 4-8ºC in Labrador Sea (Aksu et al., 1992), and cores from North Water Polynya (NOW) show cyclic changes of 2 - 4ºC for the past 8,000 years (Levac et al., 2001). Archaeological records also show major changes in the hunting modes (land- vs. marine-based) of paleo-Eskimo peoples that correspond to the NOW climate oscillations for the past 4,000 years. A new marine geology program is now studying high-resolution quantitative records of changes of sea surface parameters (temperature, sea ice) in the Canadian Arctic Archipelago (CAA) during the past 6,000 to 10,000 years using modern dinocyst assemblages as proxies. To be useful for the GCMs, the time resolution is on a scale of years to decades and the reconstructions will have a precision similar to modern oceanographic data. This precision is obtained by calibrating dinocyst assemblages from the tops of box-core samples against the oceanographic data for the core sites to develop transfer functions for paleoclimatic reconstruction. The present dinocyst database has 677 coretop samples for the circum-Arctic region. Principal component analysis shows 4 sub-regional dinocyst assemblages corresponding to the outer Beaufort Shelf, the CAA channels, the NOW Polynya and Baffin Bay. Variations in the gonyaulacoid to protoperidinioid cysts (G:P) ratio generally show similar pattern as the G:P ratio of planktonic dinoflagellates in the Canadian Arctic region and support the assumption that cysts are deposited near their sources of origin.

Aksu, A.E., Mudie, P.J., de Vernal, A., Gillespie, H. 1992. Ocean-atmosphere responses to climatic changes in the Labrador Sea: Pleistocene plankton and pollen records. Palaeogeography, Palaeoclimatology, Palaeoecology 92: 121-137.

Levac, E., de Vernal, A., Blake, W. Jr., 2001. Sea-surface conditions in northernmost Baffin Bay during the Holocene: palynological evidence. Journal of Quaternary Science 16: 253-363.

1-D-2.4

Simulation of Glacial Inception and Rapid Ice Sheet Growth in the McGill Paleoclimate Model

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A two dimensional (latitude-longitude) dynamic ice sheet model coupled to the McGill Paleoclimate Model (MPM) under computed Milankovitch forcing and Vostok-derived atmosphere CO_2 levels is used to investigate the last glacial inception and subsequent rapid ice sheet growth in the Northern Hemisphere. Since the variables in the MPM are sectorially averaged, those in the atmosphere component that are needed to calculate two-dimensional ice mass accumulation are downscaled based on the UK Universities Global Atmosphere Modelling Programme GCM. Also, in contrast to earlier MPM

studies, here the impact on ice sheet growth of the elevation effect of mountains and the freezing of rain/refreezing of meltwater are evaluated. The results show that while Milankovitch forcing only is sufficient to initiate the formation of permanent ice at around 120 kyr BP, rapid ice sheet growth during the next 10 kyr only occurs when both of the above two processes are included in the MPM. The modelled ice volume-equivalent drop in sea level during this growth period is estimated to be about two-thirds of that found from paleoclimate reconstructions. Finally, the role of the ocean and thermohaline circulation changes during the rapid ice sheet growth is also elucidated.

1-D-2.5

A Record of Environment Change of the Last 400 Years at Barrow, Arctic

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A total of 48 samples from the Core AB-67 at Barrow are analyzed for 25 grain size items and 44 geochemical items. Q-mode factor analysis applied to these data yielded 4 factors. Mapping of these factors showed their close affinity to sedimentary environment; these core sedimentary rate, precipitation, sea level change, annual temperature. Paleoenvironmentary transfer functions were defined to estimate mean annual temperature and annual precipitation from corelationship between 5 samples at core-top and observation record from Barrow Meteorology Observatory, sedimentary rate was determinated from dating by 210Pb and several environment events, and sea level from changes of sedimentary phase. The reconstructed temperature and precipitation curves show that Barrow climate is colder and drier in 16 and 17 century, temperature rose up and precipitation fluctuated sharply in 18 and 19 century, these two changes are greater in 20 century. The reconstructed temperature curves agree with the variation of assemblages of micropaleontology. Keyword: Barrow, Record, Environment Change, Q-Mode Factor Analysis, Transfer Function, 400 Years

1-D-2.6

Dynamic Process and Paleoclimatic Significance of multiple components of the grain size distribution in loess and dust storm

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Multiple components in the grain size distribution of loess and dust-storm are found and identified to record changes of atmospheric turbulence intensity in dust source area and deposited area. A time series of paleo-atmospheric turbulence intensity from 60kaBP in Loess Plateau of Asian monsoon area is firstly showed. Most of Heinrich events and Y.D. cold event are found in the sequence. It is revealed that the three patterns of atmospheric environment existed in dust source area since 60kaBP. It is noticed that climate of dust-deposited area usually changed early than that of dust source area, suggesting the effect of tropic forcing (such as summer monsoon) may be prior to ice sheet.

1-D-3.1

Sensitivity of a Regional Climate Model to the Resolution of the Lateral Boundary Conditions

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The sensitivity of a one-way nested regional climate model (RCM) to the spatial and temporal levels of information provided at its lateral boundaries is studied. To unambiguously address these two issues, a perfect-prognosis approach called the Big-Brother Experiment (BBE) is employed. It consists in first establishing a reference climate simulation (called the Big Brother) over a large domain and then using the simulated data for nesting another RCM (called Little Brother) integrated over a smaller domain. The effect of degrading the resolution of lateral boundary conditions (LBC), spatially and temporally, is investigated by comparing the big- and little-brother climate statistics for the total and fine-scale components of the fields, as well as for their stationary and transient components.

1-D-3.2

Dealing with atmospheric water in a nested RCM

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An implicit assumption in using a RCM stipulates that the atmosphere simulated by the regional model will follow the general state of the driven atmosphere. In other words, it is expected that a RCM will generate the high-resolution details without altering the large-scale atmospheric circulation. This implies that the large-scale means of the atmosphere should be similar in the RCM and in the pilot. If there are differences in the pilot and in the RCM atmosphere, they will be reflected in the hydrological cycle and could modify the nested model humidity flux divergence. Different deep convective parameterizations could be used to illustrate RCMs behavior regarding the atmospheric water content. Each convective parameterization follows particular triggering conditions and closure assumption, therefore modifying the humidity distribution and influences the hydrological cycle. The resulting atmosphere can differ from one type of parameterization to another. To illustrate the topic, an experiment is conducted with the Canadian RCM using different convective options and includes the atmospheric water budget computation. The CRCM is run for 4 months, from May to August 1988, over a domain covering USA, Mexico and the surrounding sea.

1-D-3.3

Investigation of surface hydrology simulated by the Canadian Regional Climate Model over the Québec/Labrador territory

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The Canadian Regional Climate Model (CRCM) can be used in a reality mode where it is driven by objective analyses. In this case, the model is validated using various observational datasets. We will present an investigation of the CRCM's surface hydrology from a three-year simulation conducted over the Québec/Labrador territory. In the

experiment, the CRCM was run at a 30-km horizontal grid-point spacing and driven by NCEP (National Center for Environmental Protection) atmospheric objective analyses for the period from June 1992 to May 1995. The CRCM's regional hydrologic budget will be examined and validated through comparison with observations of precipitation, temperature, snow cover and evaporation data. A validation approach using runoff data over a series of catchment basins will also be discussed.

1-D-3.4

Interaction between atmosphere and ocean-ice regional models over the Gulf of St. Lawrence

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A numerical experiment using the Canadian Regional Climate Model developed at the "Université du Québec à Montréal" (CRCM, Caya and Laprise 1999) and the Gulf of St. Lawrence ocean model developed at the "Institut Maurice-Lamontagne" (GOM, Saucier et al. 2001) investigates the sensitivity of the models to each other with a series of simulations over Eastern Canada from December 1st, 1989 to March 31st, 1990. The goal of this study is to understand the interactions between the atmosphere, the ocean and the sea-ice over the GSL using these two models. Furthermore, we want to understand the role of these interactions in the present-day climate of Eastern Canada to develop a modelling strategy to perform regional climate change scenario for this area. The simulations have been done with an iterative, uncoupled strategy, where both models run separately and alternatively, using variables from the other model to supply the needed forcing fields. The results indicate that on monthly or longer time scale, the CRCM is not very sensitive to the oceanic fields from GOM, except locally over the GSL. However, GOM is quite sensitive to small differences in atmospheric fields from the CRCM. After several iterations, the convergence of the solutions suggests that the CRCM and GOM are reaching equilibrium with respect to each other forcing fields.

1-D-3.5

Application of Artificial Neural Networks in Climatic Zonation of Pakistan

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We will analyse climate data, seasonal precipitation and temperature over the years 1971- 2000 from 39 stations spread around the Pakistan, to determine whether these distinguish the existence of climate zone in Pakistan. We obtain principle components (PC) scores using principal components analysis (PCA) with varimax rotation. Cluster analysis will be applied to delineate the climate zone of Pakistan's regions. A self-organising map, an artificial neural network algorithm, will be then employed to classify the four PC scores in an optimal fashion. We will finally compare the results of clustering analysis and neural network analysis. We will also study the temperature variability and rainfall pattern in Pakistan

1-D-4.1

L'avenir des diagnostics et leurs implications dans l'amélioration des prévisions

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Les équations diagnostiques élaborées à ce jour nous permettent d'entrevoir différentes améliorations aux techniques diagnostiques actuelles. Avec l'équation généralisée d'oméga tel que formulé par Räisänen (1995 et 1997) il est théoriquement possible d'élaborer une formulation d'équations diagnostiques n'ayant que l'approximation hydrostatique comme hypothèse. De ces mêmes équations, découle la possibilité d'évaluer quantitativement l'impact de régions délimitées de l'atmosphère sur l'évolution et la circulation de l'atmosphère en sa totalité. Le travail de Gachon (1999) offre maintenant la possibilité de quantifier les interactions entre différents forçages. Toutes ces nouvelles approches trouveront leurs utilités : dans l'identification des processus physiques entraînant le développement des systèmes météorologiques, pour apporter des explications aux modifications des initialisations des modèles apportant une importante amélioration des simulations tel qu'identifié par la méthode 4DVar, pour fournir un meilleur état balancé comme contrainte pour les méthodes d'assimilations de données 3DVar,... La présentation a pour but de faire un tour d'ensemble de ces nouvelles approches diagnostiques et de leurs possibilités pratiques, ainsi que de faire le point sur les capacités actuelles du logiciel de diagnostique DIONYSOS (Caron et al. 2002) afin de mettre en lumière les travaux futurs.

Räisänen, J., 1995: Factors affecting synoptic-scale vertical motions: A statistical study using a generalized omega equation. Mon. Weather Rev. 123, 2447-2460

Räisänen, J., 1997: Height tendency diagnostics using a generalized omega equation, the vorticity equation, and a nonlinear balance equation. Mon. Weather Rev. 125, 1577-1597

Caron, J.-F., P. Zwack, and C. Pagé, 2002: DIONYSOS: A diagnostic package for weather systems. Submitted to Q.J.R. Meteorol. Soc.

Gachon, P., 1999: Effets de la distribution de la glace marine sur le développement des dépressions à méso-échelles et sur le climat régional. Thèse de doctorat, Montréal, Université du Québec à Montréal, 352 p.

1-D-4.2

Using diagnostics of the diabatic heating contribution to the balanced state in order to initialize a meso-scale non-hydrostatic model in an idealized case

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An idealized case, where the only physical effect was a constant 1000 km bell-shaped diabatic heating region applied in the middle of the domain, was first simulated using the non-hydrostatic Canadian Regional Climate Model (CRCM). Because the model's atmosphere was initially at rest and had no horizontal temperature and pressure gradients, this model's atmosphere underwent a nearly 6 hour period of spin-up, during which sound and gravity waves were apparent, until it reached a balanced state consisting of constant vertical motions and pressure tendencies. The model was then rerun by initiating the divergent wind from diagnostics in DIONYSOS which calculated, a priori, the balanced state from the diabatic heating function. The spin-up of the initialized model run was reduced significantly. This work suggests that it will be possible to separately calculate the balanced state due to diabatic heating which could then be used as constraints in 3 and 4-Dvar model initialization schemes.

1-D-4.3

Agricultural Application of CMC's 3-D Trajectory Model

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Three recent examples are cited to illustrate the potential application of Canada's trajectory model for agricultural purposes. The model was used successfully to diagnose the source (southern Texas) of a major infestation of diamondback moths in 1995. The moths, which attack canola crops on the Canadian prairies, can not survive Canada's cold winters and are transported northward under favourable atmospheric flow, which the model simulates. In the second example, a record rain storm (375 mm in 8 hours) occurred on July 3, 2000 over southwest Saskatchewan. Samples of the rainfall and runoff waters from the storm contained pesticides not applied locally. Back trajectories demonstrated that air flowing into the storm passed over California and Texas where these same pesticides are applied. The third example involves the fate of lindane which, until recently, has been used to treat canola seed. The wide-spread planting of canola on the Prairies and subsequent volatilization of lindane represents a significant areal source in May and early June. Forward trajectories from the Prairies passed over southern Ontario where lindane was detected in atmospheric measurements. Forward trajectories were also used to indicate regions that could be potentially impacted by the long-range transport of lindane from the prairies. As well as affecting eastern Canada, significant fractions of the trajectories that were reviewed passed over Canada's north (north of 60 degrees) and the Columbia Icefields in the Canadian Rockies. The icefields were chosen as a potential receptor because of past and on-going sampling for pesticides there. These examples show that in situations where insects or non-reactive chemicals are transported on a time scale of days and a spatial scale of thousands of kilometres, the CMC trajectory model is a valuable tool.

1-D-4.4

COMM: Meteorological model, tools, data and support. An update

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For several years, MSC/RPN supported research in Universities and local forecast offices by providing a world class meteorological model (MC2) along with tools and data. MC2 has continued to evolve rapidly with the combined effort of the users community and MSC/RPN developers. Last year the new group (COMM) dedicated to this project was presented. The current COMM version of MC2 is 4.9.3, now licensed as an open source distribution including new tools for geophysical fields production and a "branch" used for wind energy mapping (see other MC2 presentation). Moreover, many users have joined the community in the last year. The presentation covers model improvements, new projects (MC2 Showcase, website, GRID...), new collaborators, as well as the enhanced support.

Depuis plusieurs années, le SMC/RPN supporte la recherche universitaire et des bureaux de prévision en mettant à disposition un modèle atmosphérique de classe internationale (MC2) avec une boîte à outils et des données. Ce modèle a poursuivi son évolution rapide grâce aux efforts conjoints des usagers communautaire et des développeurs au SMC/RPN. Le groupe COMM fut présenté l'an dernier.

La version courante du MC2 pour COMM est la 4.9.3, maintenant licencé en distribution code source ouvert, incluant de nouveaux outils pour la production des champs géophysiques et une "application" éolienne (voir notre autre présentation). Plusieurs usagers se sont joints à COMM récemment, avec un support accru; de nouveaux projets (vitrine MC2, site web, GRID …) ont aussi démarré.

1-D-4.5

Metadata in the Meteorological Service of Canada for Data Discovery, Access and Exchange

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This presentation will provide an overview of what metadata is, why it is needed, and how metadata standards affect the way the National Archives & Data Management (NADM) branch of the Meteorological Service of Canada, Environment Canada, will conduct its business. Metadata, commonly known as "data about data", describes the content, quality, condition, and other characteristics of data. Standardized metadata will allow Canadians to better access Government programs and services via the Internet. As part of Environment Canada's e-government objectives, two international metadata standards [Dublin Core (DC) and the Content Standard for Digital Geospatial Metadata (CSDGM)] will be used to represent a hierarchical approach for data discovery, data access and data exchange. Standard thesauri and controlled vocabularies for subject searches will also be utilized to ensure particular concepts or subjects will be represented in the same way during a search. While new metadata can be generated according to standards from the onset, existing metadata in legacy databases have to be made compliant to be available to users via Internet searches. NADM is testing the use of a software tool to map information from its legacy databases to the metadata standards and subsequently generate XML records, which will be stored in a repository that can be queried by any user via the Web. Tests of this mapping are being carried out on a subset of the CSDGM standard using the HYDEX (Hydrometric Metadata) database. Once this has been successfully tested and debugged, HYDEX and eventually the SIS (Climate Station Information System) legacy metadata databases will be mapped to the DC and CSDGM standards and XML records generated for potential queries, making these metadata databases accessible worldwide.

1-D-4.6

Atmospheric Energetics in AMIP2 Models

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The Lorenz energy cycle characterizes the amount, generation, transformation, and dissipation of available potential and kinetic energy. These Quantities can yield insight into the workings of real and model atmospheres. The Lorenz energy budget is computed for thirteen models participating in the Atmospheric Model Intercomparison Project (AMIP2). The models were integrated for 17 years beginning in January 1979 using observed sea surface temperatures and sea-ice extent as boundary conditions. Seasonal mean results are presented for December-January-February and June-July-

August and are compared to observational estimates derived from the NCEP/NCAR Reanalyses.

2-A-1

The North Atlantic Oscillation (NAO)

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A brief overview of the NAO will be given, including the role of the NAO in the northern hemisphere atmospheric circulation, the role of the NAO in driving the North Atlantic Ocean, the dynamics of the NAO, and recent changes in the NAO, including possible links to anthropogenic climate change. New model results will be presented showing that the recent upward trend of the NAO index is linked to diabatic forcing in the tropics, and cannot be explained by coupling between the atmosphere and the mid-latitude or Arctic Oceans. It will also be shown that the recent eastward shift in the spatial pattern of the NAO is a consequence of non-linear dynamic processes associated with the relatively high NAO index during the last 20 years of the 20th century.

2-A-2

The potential role of thermohaline circulation changes in 20th century North Atlantic climate

Tom Delworth
GFDL/NOAA

Areal mean sea surface temperatures (SSTs) over the extratropical North Atlantic are characterized by substantial multidecadal fluctuations during the 20th century. In this work we use an ensemble of experiments with a global coupled ocean-atmosphere model to identify a mechanism which may play a significant role in this variability. In one ensemble member there are pronounced multidecadal fluctuations of simulated SST which resemble the observed SST fluctuations in both amplitude and phase. The output from this numerical experiment is used as a surrogate for the real climate system to probe potential
mechanisms of Atlantic variability. It is shown that multidecadal fluctuations of the thermohaline circulation (THC) contribute substantially to the simulated multidecadal SST fluctuations, and that these fluctuations are related to large scale changes in the density structure of the upper ocean. Additional experiments are conducted which demonstrate that the North Atlantic Oscillation (NAO) is an important influence on the simulated THC by modulating the surface buoyancy flux over oceanic convective regions in the subpolar North Atlantic. Further, decadal-scale predictability is shown to exist for the THC within this particular model.

2-A-3

Meteorology in Canada: Building on the Vision

Marc Denis Everell
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Last year I presented a broad vision for meteorology in Canada for the year 2011. The talk focussed on the challenges, strategies and commitments needed to encourage the growth of meteorology from the perspective of the public, private and academic sectors within the context of that vision. This year, I would like to show how we are moving towards that vision by presenting some concrete first steps. The MSC has set in motion plans to rejuvenate its staff, reshape what it does, and retool its infrastructure. While implementing these changes, the MSC, consistent with its vision, will continue working with its partners and stakeholders in the public, private and academic sectors to grow the meteorological sector, coordinate efforts and activities, and transit to new ways of doing business.

2-B-1.1

Into the Thick of It — Sea Ice in Canadian Arctic

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Canada's marine cryosphere is an area of ice-covered ocean that extends more than 4000 km from north to south and 3300 km from east to west. Whereas the cryosphere shrinks back from the southern and eastern regions during summer, heavy ice persists over much of the Canadian Arctic throughout the year. The harsh climate and the difficulties of navigating these remote and icy waters have hindered our understanding of our vast northern ice fields. The thickness and persistence of pack ice in a region reflect the combined influences of thermal radiation, air temperature, cloud cover, snow accumulation, oceanic heat flux, ice ridging, wave action and ice drift. Whereas radiation, air temperature, snow cover and oceanic heat flux are the principal influences on the thickness of land-fast ice, ridging and rafting may be the dominant factors where the pack ice is mobile. The strength and relative importance of these influences vary significantly across the Canadian Arctic. The Canadian Arctic harbours ice at both extremes of thickness. Unusually thin and relatively undeformed wintertime ice is found in polynyas, the ice factories of the Arctic. Splendid examples are found in the Beaufort Sea (Bathurst Polynya), the Canadian Arctic Archipelago (e.g. Hell Gate Polynya) and Baffin Bay (North Water). In contrast, a harsh climate and extreme ice pressure along the northwest coast of the Canadian Arctic Archipelago create the oldest and most rugged marine ice in the world. Thus Canada offers natural laboratories for study of both the genesis and the evolutionary culmination of marine ice. There are two distinct ice populations in the Arctic, first-year ice and multi-year ice. First-year ice attains a thickness in late winter that represents the integral of the surface energy budget over the current freezing season. It therefore responds to interannual variations in the oceanic and atmospheric conditions. Second-year ice develops from first-year ice, and multi-year ice from second-year ice, through incomplete melting of floes during summer. As multi-year ice ages, it integrates the effects of climatic forcing over a decade or more in time and over thousands of kilometres. It is commonly stated that a warming climate will bring lighter ice conditions to Canadian Arctic waters. This statement must be examined critically, considering the wide inter-regional variation of ice conditions under the present Canadian climate and the importance of ice movements. The future of the Canadian marine cryosphere will not depend solely upon changing air temperature, but will reflect the impact of climate change on a wide range of environmental factors.

2-B-1.2

Arctic Climate Variability Revealed by North Pole Drift Stations

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The mass balance of sea ice in the Arctic is not solely important on the local scale but also on a global scale through its albedo and freshwater effect. The Arctic Oscillation (AO) and Arctic Ocean Oscillation (AOO) are thought to explain a great deal of the climatic variability in this region. The associated circulation patterns are characterized by index time series which we use to explore the relationship between these large-scale modes of climate variability, the local meteorological conditions and via a one-dimensional model, variation in the sea ice mass balance. From 1954 to 1991 a total of 31 manned meteorological stations drifted in the Arctic. During this period, a minimum of one or two ice stations were continuously collecting 4 to 6-hourly meteorological data.

Most of the data represent the Central Arctic Ocean, East Siberian, Beaufort and Chukchi Seas. Some of the meteorological variables collected are: surface air temperature, sea level pressure, cloud amount, wind speed, relative humidity and snow depth. We present results of various statistical analyses based on these data. These data are also used to force a 1-D thermodynamic sea ice model, which calculates shortwave and longwave radiation, ice thickness and duration of the melt season. The model's output and the meteorological variables mentioned above are correlated with the AO and AOO for different regions in the Arctic. The explained variance and trends are then compared between regions.

2-B-1.3

Streamfunction, Freshwater and Heat Content in the Arctic Ocean - Results from the Arctic Ocean Model Intercomparison Project

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Results from the first stage of the Arctic Ocean Model Intercomparison project are presented. Therefore, output from six sophisticated coupled sea ice-ocean-climate models are intercompared in order to investigate vertical integrated properties of the Arctic Ocean. Annual mean Streamfunction, integrated from top to bottom and freshwater and heat content, integrated over the upper 1000m of the water column are shown together with their annual ranges. The differences between the individual model representations are evaluated with respect to possible causes. The model derived streamfunctions show differences in their pattern as well as several Sverdrups in magnitude. The evaluated annual mean heat content in the Canada Basin varies from -3.5 GJm^{-2} and + 1.8 GJm^{-2} between the models, representing both too cold and too warm solutions compared to the climatology. The corresponding freshwater content shows as a dominant feature a maximum in the Beaufort Sea, where values vary between 6~m and 24~m for the individual models. Differences occur as well for the annual range, where especially streamfunction is subject of significant variability. The indicated differences between the models are partially caused by inequalities in model resolutions and model parameterizations, but in the current stage of the project, where only existing results are compared, external forcing, especially the applied windstress, contributes significantly. This study is a first step on the way to identify biases between different model approaches and their possible origins and will serve as a base for upcoming studies, where all models will be executed with common forcing.

2-B-2.1

A New Synoptic Climatological Approach to Identify Severe Ice Storms: Application in Ottawa

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Freezing rain is a major weather hazard which can result in significant disruption to transportation, and damage and disruption to built infrastructure such as telecommunication towers and transmission wires. In this study, an automated synoptic climatological procedure is used to assess the risks for Ontario communities to severe ice storms and has the potential to be adapted for prediction of severe freezing rain events. Principal components analysis, the average linkage clustering procedure and discriminant analysis is used to classify the distinctive synoptic categories that are associated with the occurrence of freezing rain. Preliminary work has been undertaken for Ottawa using meteorological data that include the hourly surface observed and 6 levels of 6-hourly NCEP upper-air reanalysis weather variables for the period 1958-2001. The data have been divided into two parts: the learning data set (1958-1991) was used to develop the model and the testing data set (1991-2001) was used in the model validation. The procedure is able to identify weather types which are the most highly associated with freezing rain storms. The stepwise logistic regression was performed on all days within the freezing rain weather categories to analytically determine the meteorological variables that can be used as forecast predictors for the likelihood of freezing rain occurrence. The preliminary results show that the model is best able to identify freezing rain events of longer duration. For example, in the test or validation dataset, for likelihood values >=0.6, the procedure was able to identify greater than 75% of all significant freezing rain events with a duration of 6 hours or longer.

2-B-2.2

Orographic influences on the mesoscale structure of the 1998 ice storm

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The Ice Storm of 5-9 January 1998, affecting the northeastern United States and the eastern Canadian provinces, was characterized by freezing rain amounts greater than 100 mm in some areas. The region of maximum precipitation occurred in a deformation zone between an anomalously-cold surface anticyclone to the north and a surface trough axis extending from the Gulf of Mexico into the Great Lakes. Mesoscale processes were examined to understand their role in regulating the persistence, phase and intensity of the event. The persistently cold near-surface air in the precipitating region was linked to orographic channeling of cold air from the surface anticyclone to the north. The position of the surface-based freezing line was strongly tied to orographic funneling during the first period of freezing rain (4-7 January), while this channeling contributed to the depth of the cold air north of the US border and governed details of the position of the freezing line in the Lake Champlain valley during the second period (7-10 January). A frontogenetical focus within the St. Lawrence, Ottawa and Lake Champlain valleys was provided by orographic channeling of the cold air in combination with geostrophic southerlies in the warm air. The frontogenesis was an important contributor to the higher precipitation amounts during the first period of freezing rain and locally enhanced precipitation within the broad-scale heavy rain of the second period. A discussion of the expected predictability of such events is provided.

2-B-2.3

Stochastic Modelling of Ice Accretion on a Non-Energized Station Post Insulator under Freezing Rain Conditions

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Understanding ice build-up on large complex structures during freezing precipitation is of great importance in an industrial context, particularly in designing transmission lines and their insulators which may experience flashover. The focus of our research is on the numerical simulations of ice accretion on a station post insulator under freezing rain conditions. This has not been accomplished heretofore because of the complexity of the insulator string with its numerous sheds, and because of the complexity of the resulting ice accretion with numerous icicles. In order to tackle this problem, we have developed a morphogenetic model, a hybrid of ballistic trajectory and random walk models. This model is able, in principle, to simulate the variety of ice accretion shapes which occur as a function of temperature, wind speed, precipitation rate and water droplet size. This is the first time that such a model has been applied on such a large scale, and in particular to a station post insulator. The model prediction of ice accretion morphology on the insulator is analysed as a function of the microscopic model parameters. In the future, comparisons will be made with the results of icing wind tunnel experiments undertaken at the University of Quebec in Chicoutimi. The project is within a program of CIGELE in collaboration with the University of Alberta.

2-B-2.4

Diagnosing Snowfall Density

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Large sectors of the economy (e.g., transportation, construction, agriculture, commerce) are affected by snow. The economic and social value of accurate quantitative precipitation forecasts (QPFs) of snow is well recognized, but is constrained by the complexities of precipitation generation and variations in its density. Cloud microphysical research suggests that many factors contribute to the structure of snowflakes, including crystal habit, crystal growth, aggregation, riming and melting. These structures, in turn, relate to the density of the snowfall by virtue of the relative proportion of the occupied volume composed of air. Although the complexity is considerable, there is some expectation that the bulk effects of these processes on snow density can be assessed through reference to the profiles of temperature and moisture within and below the cloud. Snow density class (heavy, average, light) is diagnosed from radiosonde data through the application of an ensemble of artificial neural networks. Seven variables were used as inputs to the neural networks. Principle component analysis was used to extract a set of 6 orthogonal factors from the raw surface and sounding data, and the seventh variable, a month index, was added to represent the solar cycle. Key performance measures, such as the probability of detection (POD), false alarm ratio (FAR), bias and critical success index (CSI), are used to assess diagnostic skill. The results, using an independent test dataset, show substantial skill in detecting snow density class for all categories. Application of a method for uniquely interpreting the ensemble output

reveals links between the inputs and class designated by the neural networks that are physically meaningful based on cloud microphysical understanding.

2-B-3.1

PRUDENCE: Prediction of Regional scenarios and Uncertainties for Defining European Climate change risks and Effects

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PRUDENCE is a new European-scale investigation (with 21 collaborating institutions) funded by the European Union with the objectives: to address and reduce deficiencies in projections of future climate change, to quantify confidence and the uncertainties in predictions of future climate and its impacts, using an array of climate models and impact models and expert judgement on their performance, to interpret these results in relation to European policies for adapting to or mitigating climate change. Climate change is expected to affect the frequency and magnitude of extreme weather events in response to higher temperatures, an intensified hydrological cycle and more vigorous atmospheric circulations. Four major limitations in previous studies of extremes have been: 1. a lack of appropriate computational resolution, which limits or even precludes the analysis of extremes; 2. an absence of long-term high resolution climate model integrations, which drastically reduces the statistical significance of any simulated changes in extremes; 3. poor co-ordination across climate modelling groups, which limits the ability to compare different studies; 4. a limited use of high-resolution model output by impact analysts, which severely restricts any evaluation of the utility of such output for impact assessment. These four issues are all thoroughly addressed in PRUDENCE, by using a suite of state-of-the-art high resolution global and regional climate models, ensuring that model simulations span a statistically meaningful time period (30 years), co-ordinating the project goals to address critical aspects of uncertainty, and applying impact models and impact assessment methodologies to provide the link between climate information and its application to serve the needs of society.

2-B-3.2

Preliminary results from a 50 km variable-resolution regional climate simulation performed with the GEM forecast model.

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Preliminary results from a regional climate run performed with the GEM forecast model are presented which use the latest distributed-memory version of the model in a variable-resolution mode. The domain's high-resolution area covers all of North-America with a uniform 50 km mesh. Elsewhere, the resolution gradually decreases to that of a 200 km mesh. This type of simulation is a necessary step in validating the variable-resolution approach for regional climate studies and more specifically, it is also a cost effective means of evaluating the physics configuration that is being considered for the upcoming meso-global long-term forecast model at CMC/RPN.

2-B-3.3

Evaluation of the mass-flux convection schemes of the Canadian RCM over the region of Mexico

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One of the major physical processes that affects the dynamics and energy of atmospheric circulation systems is the cumulus convection. Hence, it becomes necessary to represent the net effect of an ensemble of convective clouds upon the atmosphere in terms of the grid-scale parameters. This conference is devoted to the Kain-Fritsch cumulus parameterization and the new bulk mass flux convection parameterization for deep and shallow convection developed by Bechtold, hereinafter referred to as Bechtold scheme, both employed in the Canadian Regional Climate Model. The region chosen corresponds to Mexico since it includes a tropical climate, a steep topography and, during the fall, heavy precipitations are frequently observed. This constitutes a combination of conditions rarely present in a RCM simulation. The simulation was carried out with the CRCM for fall 1989 with a 15 min. timestep. The computational domain is centered over central Mexico, with 130 by 100 grid points in the horizontal with nominal grid spacing of 45 km, and 18 Gal-Chen scaled-height layers in the vertical. In order to validate the convection scheme, we have compared their performances with the dataset of monthly terrestrial surface climate from CRU. Both convective schemes, Bechtold et *al*. (2001) and Kain and Fritsch (1990), have a closure assumption based on the removal of the Convective Available Potential Energy (CAPE). Their cumulus cloud model formulation uses a one-dimensional entraining/detraining plume. The stratiform component of the precipitation is obtained from the large-scale condensation part of the second-generation general circulation model (GCMii). The RCM was driven by the NCEP (National Centers for Environmental Prediction) reanalysis at the lateral boundary. The results suggest that the schemes provides reasonable and efficient solutions in terms of predicted rainfall, cloud top heights and temperature and moisture structures. Hence, the convection parameterizations give an efficient and reasonable numerical description of atmospheric convection.

Kain, J. S., and J. M. Fritsch, 1990: A One-Dimensional Entraining/Detraining Plume Model and its application in convective parameterization. J. Atmos. Sci., 47, 2784-2802.

Bechtold, P., E. Bazile, F. Guichard, P. Mascart, and E. Richard, 2001: A mass flux convection scheme for regional and global models. Q. J. R. Meteorol. Soc., 127, 869-886.

2-B-4.1

The New Model for Calculating Wind Chill in Canada and the United States

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Wind chill reporting in Canada and the US changed in 2001, with the abandonment of Siple and Passel's classic equation and the adoption of a new equation based on a mathematical model of the cooling of a face in wind. The new model and the assumptions inherent in it, will be described, and its limitations discussed. The old wind chill, despite its faults, was a useful for assessing the relative severity of winter weather conditions. We will show why this was so, and how the new and old wind chill calculations are related.

2-B-4.2

The Effect of Cold Wind and Wetness on the Skin Temperature, Heat Loss and Thermal Conductance

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Skin heat loss and tissue thermal resistance are essential variables for modeling heat transfer from the face in cold winds and for the development of a reliable wind chill index. The objective of the present study was to measure skin temperatures (Tsk) and heat losses (Hsk), and to calculate, using the inside surface cheek temperature, the tissue thermal resistance (R) of the cheek during exposures to cold winds and wetness. Twelve subjects (6 males and 6 females) were exposed to four 90 min tests where the wind intensity changed from 2 to 5 to 8 m/s at 30 min intervals. The tests were conducted at 10, 10 (wet), 0, and -10°C. In the wet test at 10°C, a fine mist of water was spayed to the face of the subject every 15 sec. During the tests, the subjects were dressed for thermal comfort, walked on a level treadmill at a speed of 4.8 km/h and were facing the wind with their face fully exposed. At 10°C, the last 10 min average (±SD) when steady-state was achieved in most cases for Tsk, Hsk and R varied from 23.0 ± 2.8°C, 280 ± 55W/m², and 0.045 ± 0.013°C m²/W at 2m/s to 18.3 ± 2.6°C, 329 ±63W/m², and 0.049 ± 0.017° Cm²/W at 8m/s. At 0°C, the last 10 min average for Tsk, Hsk and R varied from 17.7 ± 2.2°C, 370 ± 66W/m², and 0.048 ± 0.014W/m² at 2m/s to 11.9 ± 2.1°C, 467 ± 120W/m², and 0.049 ± 0.016° Cm²/W at 8m/s. At -10°C, the last 10 min average for Tsk, Hsk and R varied from 13.4 ± 2.4°C, 485 ± 72W/m², and 0.044 ± 0.012W/m² at 2m/s to 9.3 ± 2.5°C, 963 ± 229W/m², and 0.027 ± 0.008° Cm²/W at 8m/s. The wet exposure at 10°C decreased Tsk on average by 5°C and increased Hsk by 100W/m² as compared to the dry exposure to the same temperature. The decrease of R at –10°C (5 and 8m/s) was attributed to cold-induced vasodilatation (CIVD). It was concluded that the thermal resistance of the cheek tissue averages 0.051° Cm²/W and is not dependent on ambient temperature and wind intensity in the absence of CIVD. When CIVD is present, R is inversely related to the wind intensity.

2-B-4.3

Wind Speed and Blowing Snow for the Canadian Prairie and Arctic

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Blowing snow has major implications for transportation and the atmosphere-surface water and energy balance. The goal of this study is to improve blowing snow forecasts on the Canadian Prairies and Arctic using a combination of standard meteorological data and modeling techniques. The focus is to investigate ways of determining when blowing snow is most likely to occur (and when it will not occur) and how much the visibility is reduced during these events. The wind speed associated with blowing snow was examined using a large database consisting of up to 40 seasons of hourly observations at 15 Prairie and 17 Arctic sites. Instances of blowing snow were divided into cases with and without concurrent falling snow. The latter group was further segregated by time since the last snowfall. An empirical scheme was developed relating wind speed, air temperature, time since last snowfall and visibility. Incorporating the time since last snowfall produced an improvement in the discrimination of blowing snow and non-blowing snow cases. Including a factor for wind gusts also showed value. The probability of any given visibility is a function of wind (speed and direction), air temperature and time since last snowfall. The lower the target visibility, the stronger the influence of temperature and time of last snowfall. The empirical scheme was tested against actual hourly observations using the false alarm ratio (FAR), probability of detection (POD) and credibility (CRED). The values of these parameters varied widely depending on the location of the station (lee of mountains and land cover type) and wind direction bias. Particular improvement in the FAR is apparent when accounting for wind direction biases.

2-B-4.4

A pilot study on drifting and blowing snow

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Drifting (near the surface) and blowing snow (i.e. snow that has fallen to the ground and is later picked up by strong winds) can be a serious traffic hazard in the Canadian winter. It can affect road and air travel, is a significant cause of traffic accidents and is an important factor in winter road maintenance. As a step towards improving our understanding and predictive capacity of drifting and blowing snow we are conducting a small scale study of wind speed and blowing snow occurrence at a site near Horning's Mills, Southern Ontario this winter. Continuous measurements are being made of wind profile, temperatures and snow depth (with an acoustic sensor). It is hypothesised that falling and blowing snow events are characterised by large variances in individual snow depth measurements relative to 15 min average values, and we are testing this by comparison with visual observation. We are also attempting to measure particle size distributions on an occasional basis with a replicator". Lessons learned from this study will be used to refine the field measurement in a more extensive program proposed for several sites across the country.

2-C-1.1

Preliminary Meteorological Look at an Extreme Precipitation Event in the High Arctic

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There have been ongoing debates about climatological trends in extreme weather events around the globe. These concerns also apply to the high arctic in terms of anomalously high air temperatures, increased frequency of freezing rain and rain and increased cyclonic activity. Increases in these elements and synoptic activity play a major role in the physical changes that occur in the snow, sea-ice and terrestrial surfaces. Biological impacts also result from the physical changes that take place on the surface (e.g. seal and polar bear habitat and sub-ice primary production). The Spring of 1994 was one of the warmest on record in the Resolute Bay area and had the earliest significant rain event ever recorded (May 26). The rain event was wide spread in the Hgh Arctic extending from Resolute, through Cambridge Bay and into the Mackenzie Region. A major sea-ice field experiment was being conducted near Resolute during the event (Seasonal Sea-Ice Monitoring and Modeling Site (SIMMS)) which saw a very rapid change in snow and sea-ice evolution because of the event. A preliminary atmospheric circulation and surface meteorological analysis of the event will be presented with reference to some of the physical changes that took place in the snow and sea-ice during SIMMS'94. Possible links to the Arctic Oscillation (AO) are also investigated. The case study is useful for determining circulation patterns associated with these anomalous events.

2-C-1.2

Development of the WATCLASS model

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The WATCLASS model is a distributed hydrologic model that includes a detailed simulation of the energy and water balances within a watershed. Testing of WATCLASS centers on the partitioning of precipitation into runoff, evaporation and moisture storage. While runoff data in the form of streamflow is widely measured other quantities such as evaporation and storage are not. Of primary concern in the WATCLASS linkage is the ability to calibrate on streamflow data alone and provide improved representation of latent heat flux to atmospheric models. Because a majority of the validation data is available at the point scale, streamflow generation theory and controlling parameters are developed at a fine scale and used at progressively larger scales. Part of this study is to develop parameters at fine scales, transferable to the larger modelling area such that streamflow, the most widely available validation data set, is well represented. Snow processes play a key role in accurately representing the water and energy balances. The authors have investigated several possibilities, including changing the maximum snow pack density for forests and shallow snow packs, altering the snow redistribution algorithm, including mixed precipitation, incorporating a variable fresh snow density, improving snowfall canopy interception, and splitting the WATCLASS soil state variables. A major issue in the coupling of land surface schemes to hydrologic models is parameterization of the soil-moisture budget. Many hydrologic models use non-linear storage reservoirs to characterize the near surface and deep groundwater supplies. These reservoirs are not necessarily associated with volumetric soil moisture or water table position. Nevertheless, they satisfactorily model the vertical drainage and horizontal movement of water towards the stream, both of which are well characterized by the total amount of water available in the soil. WATCLASS results, incorporating these processes and parameterizations, are presented for the BOREAS data sets.

2-C-1.3

Synthesis of water and energy fluxes over the Mackenzie River Basin during the 1998-99 Water Year

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An important component of the Mackenzie GEWEX Study (MAGS) was a comprehensive study of the 1998-99 water year over the Mackenzie River Basin (MRB). During this year, a number of enhanced measurements of atmospheric soundings; radar; aircraft and flux towers, hillslope runoff; additional surface stations; discharge; remote sensing of solar radiation, snow, and vegetation and ice; and special numerical weather prediction simulations were carried out. This enhanced observation period was termed the Canadian GEWEX Enhanced Study (CAGES). The major objective of CAGES was to provide the additional information required to improve our understanding of the Mackenzie Basins water and energy fluxes and reservoirs through an entire annual cycle, and to test our improving understanding of the processes controlling these fluxes/reservoirs and our ability to model them. The 1998-99 water year was characterized by a transition to La Nina conditions, warmer than average surface air temperatures, average precipitation the MAGS region, but above average in the northern sections and below average in the southern sections., average discharge, the earliest break-up of Great Slave Lake, and hail and heavy snow in the central regions of the basin. La Nina conditions prevailed throughout the MAGS year. Consistent with the strong La Nina conditions the PNA (Pacific North American) pattern was strongly negative in conjunction with a weakened Aleutian low. Two other important indices, namely the NAO (North Atlantic Oscillation) and the AO (Arctic Oscillation) appeared to oscillate about their neutral values without any significant deviations. Prior studies have found an increase in the frequency of atmospheric blocking in the Pacific sector during the negative phase of the PNA and La Nina winters. We will examine this form of low-frequency variability in relation to its impacts upon the North Pacific storm track and temperature anomalies within the MAGS region.

2-C-1.4

Atmospheric Deposition of Major Ions and Trace Metals to a Maritime Boreal Watershed, Avalon Peninsula, Newfoundland

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Atmospheric pollutants (e.g. anthropogenic SO_4 and NO_3 and trace metals) arrive at the surface in Newfoundland via long-range transport from mainland North America and from point sources within the province (fossil fuel power plants, pulp and paper mills, mines, and a petroleum refinery). The sensitivity of Newfoundland surface waters to acid deposition is rated high to extreme over more than half of the island. Despite significant reductions in SO_2 emissions in the eastern United States and Canada over the past two decades, there has been no corresponding general decline in SO_4 loading to Newfoundland lakes or any increase in pH for surface waters. This raises questions about the relative importance of long range transport versus local/regional sources of atmospheric deposition in the region, their impacts on freshwater ecosystems, and the potential effects of climate change on these processes. Here we report on investigations carried out since 1999 in a 110 km^2 watershed on the Avalon Peninsula involving precipitation chemistry, hydrometeorology and hydrogeochemistry and aimed at quantifying budgets of major ions and trace metals within the basin. Back-trajectory analysis of a variety of incoming airflows, together with stable isotopic methods, are used to identify source regions. The wet deposition chemistry is highlighted in relation to precipitation magnitude, type, and accompanying synoptic-scale weather patterns for portions of the contrasting hydrometeorological years 1999-2000 and 2000-2001. Stream discharge and chemistry provide a basis for estimating pollutant loads exported from the basin. These results are discussed in the context of recent trends in atmospheric pollution over Newfoundland and Labrador. Keywords: atmospheric pollution, boreal watersheds, wet deposition, stable isotope analysis.

2-C-2.1

Offshore Transport of Heat, Nutrients and Larvae by Haida Eddies from British Columbia Coastal Waters

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Haida Eddies are anti-cyclonic features that form in winter along the eastern continental margin of the Gulf of Alaska, west of the Canadian Queen Charlotte Islands. Their number and size vary with winter sea levels, currents and temperatures along the coast. The largest eddy observed to date, Haida-1998, carried offshore about 5,000 cubic kilometers of coastal water, a volume comparable to that of Queen Charlotte Sound and Hecate Strait combined. These two seas are the main source basins for eddies. The offshore heat flux by this eddy may be one-quarter to one-half the northward heat transported along the Canadian continental margin west of Vancouver Island during the winter of 1997/98. Offshore eddy heat flux in other years may be a similar fraction of northward flux. Through its natal summer, Haida-1998 lost nitrate from core waters at 3 times the rate we have historically observed in the Gulf of Alaska (at stations P16 or Papa). Nitrate supports new production, which is the portion of primary production that results in biomass increases. Eddies may also carry Pacific cod larvae offshore in winter, away from spawning and rearing grounds in Hecate Strait. We investigate this hypothesis by using winter, pressure-adjusted sea level at Prince Rupert, in northern British Columbia, as a proxy for offshore transport of Hecate Strait waters in winter. Pacific cod are recruited into fisheries at age three. Correlation between fisheries catch and winter adjusted sea levels at -3 years are consistently high over 40 years of data, and provide good support for this hypothesis.

2-C-2.2

Interannual sea level variability over the Scotain Shelf and Slope in the 1990s

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The TOPEX/Poseidon altimeter data over the period from 1992 to 1999 have been analyzed to examine interannual sea level variability over the Scotian Shelf and Slope. A modified orthogonal response analysis is used to simultaneously remove the annual cycle and residual tides. Altimetric data reveal significant interannual sea level variability of magnitude of 5-10 cm over the shelves in the 1990s, falling to the lowest in 1994, then rising to the highest in 1997-98 and falling again afterwards. The second sea level decrease shows an overall equatorward propagation. The altimetric results are generally consistent with those detected from detrended coastal tide-gauge data at Halifax, Nova Scotia. The interannual sea level variability is thought to be forced by fluctuations of the Gulf Stream position and of the baroclinic Labrador Current transport which in turn seems to be related to the North Atlantic Oscillation.

2-C-2.3

Observations and simulation of the seasonal variability of the Strait of Georgia

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The Strait of Georgia is a large semi-enclosed basin on the southern Coast of British Columbia. The main connection to the Pacific ocean is Juan de Fuca Strait to the south through which the estuarine circulation, mainly driven by the Fraser River outflow, forces a two-way exchange with the ocean shelf water. The resulting coastal circulation is the result of tidal forcing, wind stress, and freshwater input. Both the local wind stress and the freshwater discharge follow a strong seasonal modulation which result in strong seasonal cycles of the water properties of the system. Several long term time series have been examined in terms of seasonal response and the results are compared with output from several numerical simulations. The Princeton Ocean Model (POM) is used here and forced with tides and seasonal wind stress and freshwater discharge. The model is integrated over several years, until the system approaches statistical equilibrium. The model results show good agreement with the data in Juan de Fuca Strait, as well as for the upper part of the water column within the Strait of Georgia. However, it appears more difficult to simulate the seasonal cycle of the deeper water of the Strait which results from a complex balance between mid-water intrusions from the sill area and local mixing.

2-C-2.4

Coastal storms and storm surges in the Canadian Beaufort Sea: a geological perspective

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Much of the Canadian sector of the Beaufort Sea coast consists of unlithified but frozen coastal bluffs. Although the sea is frozen for 8 months of the year, coastal storms and associated high water levels during the short open water season cause coastal retreat which averages 1-2 m a^{-1}. Short-term erosion rates, caused by intense fall storms can be much higher. The climatology of these storms along with associated water levels and sea ice distribution were investigated as part a study of the impacts of climate change on the Beaufort Sea coast. Storms were identified and severity was estimated using synoptic wind speed data from coastal stations for 1962-1999 (Environment Canada). Only storms characterised by local NW winds (capable of producing surges) were examined. There is considerable variability in frequency and severity at interannual and decadal scales. The periods from 1962-1965 and 1981-1985 were notable stormy intervals, however, the infrequent most severe events are not necessarily embedded within these periods. The water level record from the Tuktoyaktuk tide gauge reveals a distinctive seasonality with the highest mean water levels occurring during August and the lowest in March. The difference in mean water level is 0.3 m, which is similar in magnitude to the tidal range. Storm surges are associated with NW storm winds at Tuktoyaktuk, but the local winds are a poor predictor of maximum water level. Sea ice distribution was based on the Canadian Ice Service weekly ice charts, 1968-1998. The percentage of open water defined by the 5/10 ice edge within an polygon extending from Barrow, AK to Banks Island was highly variable interannually and decadally. There appears to be a trend in the 1990s to increasing open water extent just prior to freeze-up.

2-C-2.5

Numerical Studies of Seasonal Circulation in the Western Caribbean Sea

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A three dimensional ocean circulation model known as CANDIE is used to study circulation, water mass distributions and their seasonal variabilities in the western Caribbean Sea. The model horizontal resolution is roughly 18 km. The model is forced by the monthly mean temperature and salinity, monthly mean COADS surface wind stress and heat flux, and monthly mean transports across the model open boundaries estimated from the coarse-resolution model results for the entire Atlantic produced by the FLAME. The regional western Caribbean Sea model is initialized with the January mean temperature and salinity and integrated for three years. The model results reproduce many well-known circulation features in the region, including the persistent throughflow known as the Caribbean Current, the cyclonic Panama-Colombian Gyres, and strong seasonal variabilities of temperature and salinity in the surface mixed layer. The model calculated annual mean transport across the Yucatan Strait is about 22 Sv, which is comparable with the previous estimates. We also compared the model currents with the observations made in the region. Vertical distributions of the model currents along the Yucatan Strait agree reasonably well with the current observations made by Pillsbury (1887) and most recently by Sheinbaum et al. (2002).

Pillsbury, J. E., The Gulf Stream - A description of the methods employed in the investigation, and the results of the research, report Appendix 10, pp. 461-620, U.S. Coast and Geodetic Survey, Silver Spring, Md., 1890.

Sheinbaum, J., J. Candela, A., Badan, and J., Ochoa, Flow structure and transport in the Yucatan Channel, Geophys. Res. Lett. (in press), 2002.

2-C-3.1

On modelling the 1D atmospheric boundary layer

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Several simple, commonly used, turbulence closure schemes for the Atmospheric Boundary Layer (ABL) include turbulent kinetic energy (TKE) and turbulent length scale equations. The length scale equation can either be diagnostic or prognostic. The prognostic equation is often that for the TKE dissipation, epsilon. These models (E-l, E-epsilon and its modified versions, and two versions of the Mellor-Yamada q2l Level 2.5) are applied to simulate the neutral, nocturnal and diurnal cycle situations in a simple one-dimensional atmospheric boundary layer configuration. Results obtained with the models are compared and discussed. There seem to be persistent difficulties with E-epsilon and q2l closure schemes in that they predict too large turbulent scales and boundary-layer depths. This can be linked to under production of epsilon in the upper part of the boundary layer, leading to increased E and l. With suitable modification to the epsilon equation, we can obtain similar results from E-epsilon closure to those with E-l closure.

2-C-3.2

Summer Surface Level Ozone over Lake Ontario

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The Great Lakes are known to influence local patterns of summer surface level ozone concentrations, as shown by both shoreline and more limited over-lake measurements. Environment Canada equipped a Great Lakes meteorological buoy with an ozone analyzer for summer 2000, in collaboration with other experimental air contaminant programs. Preliminary analysis shows how over-lake concentrations vary in comparison with shoreline measurements, and provides information on ozone levels and flows in an area that is both a boundary district and a prime recreation venue in Eastern Canada

2-C-3.3

Numerical simulation of one atmospheric boundary layer in natural convection

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The aim of this paper is the numerical simulation of experiment carried out in laboratory by Willis and Deardorff 1974. It consists of the heating by bottom of one layer of fluid presenting a stable stratification initially. This experiment is in fact a simulation in atmospheric laboratory of one boundary layer evolving moving in natural convection. To lead to the mathematical model treating evolution of one boundary layer in free mode of convection, we borrowed two ways: (a) The first consists in writing the equations of evolutions until the second order and this by expressing the triple correlation terms appearing well using some models; we obtain the double correlation model. (b) The second way consists in incorporating the modeled triple correlation terms to the principal unknown factors of the problem and writing the equations consequently, this led to the triple correlation model. After application of hypotheses of closing and the debugging of stable algorithm, a numeric code was worked out to predict the processes of vertical transfers in the layer of natural convection. The numerical results obtained are compared

with the experimental results of Willis and Deardorff and LES/DNS data (Large-Eddy Simulation, Direct Numerical Simulation.

Willis G.E, Deardorff. A laboratory model of the instable planetary boundary layer Bound Layer. Meteor., 31, pp 1297-1307 \\ 1974
Deardorff J.W., Willis G.E,: " Further results from a laboratory model of the convective planetary boundary layer", Bound. Layer. Meteor., 32, pp 205-236 1985
V.M. Canuto, F. Minotti, C. Panchi, R.M. Ypma, O. Zeman. Second order closure PBL model model with a new third - order Moments: comparison with LES data J. Atmosph. Sc., 51, 12, pp 1605-1618 1994.

2-C-3.4

Lagrangian Simulation of Suspended Particles in Neutrally-Stratified Surface Boundary Layers

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The vertical equation of motion for suspended particles in a neutrally stratified, near-surface, boundary layer is solved for the particle motion. Drag on the particles is computed assuming that the fluid velocity at the particle location can be modelled by a generalised Langevin equation. The treatment of reflection or bounce of particles at a solid, lower boundary is discussed and results are obtained for neutrally buoyant particles and for heavy inertial particles with gravitational settling. It is shown that the effective settling velocity and the effective turbulent diffusivity for particles are reduced, relative to terminal fall speed in still air and standard boundary-layer assumptions, because of inertial effects near the wall. Particle concentration profiles can depart from the standard power-law form, associated with Prandtl and Rouse. Basic results are from 1D Lagrangian simulations but preliminary results from 2D simulations will also be included.

2-C-3.5

Adverse Effects of Open-Air Burning of Hard Drugs (A Case Study of its Boomerang Effects on Lagos, South-West Nigeria)

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Atmospheric pollution caused by open-air burning of 4 tonnes of seized hard drugs (cocaine, heroines, Indian-hemp) is considered. Its effects on human beings are also emphasised. The burning exercise which took less than one hour, initially produced pollution that was confined to the radial distance of less than 1.5 Km away form the source. It later led to heavy pollution, which extended more than 17 Km from the source. It lasted for more than 5 hours. The adverse effects on the visibility and human health were enormous. The meteorological conditions responsible for pollution plume dynamics are studied with a view to determining its spatial and temporal behaviour. The study has shown that meteorological factors play a key role in the persistence or dispersal of polluted air. Investigations showed that the proper or improper dispersion of gaseous pollutants are affected and aided meteorologically. The 1,500m deep quasi-static cyclonic system over the south-western part of Nigeria coupled with strong convective activity made it possible for the generated pollutant to be hovering. The replacement of this cyclonic system by anti-cyclonic ridges at 900m(900 Hpa level) and 1,500m(850 Hpa level) resulted in subsidence.

2-C-4.1

Operational UMOS system at CMC

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With increasing reliance on the output of computer models for forecast parameters, Model Output Statistics (MOS) has become a more and more useful statistical technique for weather element post-processing. In the MOS framework, observed values of the predictand are correlated with forecast values of predictors valid at the same time. The advantage of this approach is that the systematic errors that the model have in forecasting the predictor are removed. Generally, MOS is more reliable than PP but will tend toward the climatology of the development sample with increasing projection time. The disadvantage of MOS is that it is dependent upon the characteristics of the NWP model used to generate the predictors in the dependant sample. To alleviate this problem, the Canadian Meteorological Centre implemented an Updatable Model Output Statistics (UMOS). UMOS is the same as MOS. Unlike the traditional methods where data are collected over time and equations developed from the resultant data set and then used with little or no changes for a relatively long period of time, UMOS involves regular updating of the statistical relationships. At CMC there is an automatic daily preparation of the data for statistical processing followed by a weekly redevelopment of the equations to be used to forecast weather elements. To ensure a smooth transition across model changes and across seasons, a weighting scheme is employed using data prior to and after the change to develop the weekly equations. Verification results comparing the PP (Perfect Prog), UMOS and direct model outputs for temperatures, winds and probability of precipitation will be presented.

2-C-4.2

Adaptation of the Canadian Updateable Model Output Statistics System to the Great Lakes Marine Wind Forecast Programme

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The success of the Updateable Model Output Statistics (UMOS) system developed and implemented by the Meteorological Research Branch and the Canadian Meteorological Centre of the Meteorological Service of Canada has inspired the adaptation of this system to the forecast of surface winds on the Great Lakes. A distinctive challenge of this forecast problem arises from the removal in the autumn of the moored buoys, which supply the marine forecaster with in-situ observational data most representative of the off-shore marine environment. The UMOS system provides an effective means of circumventing the resulting constraint on the size of the observational database available for a MOS approach to post-processing the raw model output on the Great Lakes. Further augmentation of the observational database can be achieved by pooling the samples for all of the buoys reporting on a particular lake, in the expectation that the buoy responses in the off-shore marine environment would be much less idiosyncratic than terrestrial stations. This amounts to a sacrifice of the resolution of some finer scale mesoscale features for a more stable solution in the coarser mesoscale and sub-synoptic regimes. In this paper we will present some of the preliminary results obtained from the application of UMOS to the Great Lakes marine forecasting problem, as well as touching upon those strengths and limitations of the system as a development tool which became apparent during the course of this work.

2-C-4.3

Assimilation of observation data into SCRIBE

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Automated weather forecasts for all regions of Canada have been available for quite some time based on the SCRIBE expert system. The system has until now been restricted to using guidance from the numerical weather prediction (NWP) models and their derived statistical outputs either Perfect Prog (PP) or updateable Model Output statistics (UMOS). In practice, this means that the generated forecasts are solely based on model data, without any explicit observation data. A system is under development that will merge the SCRIBE concepts with the latest local observations, using a statistical approach. This paper describes the architecture of the system and the different approaches that will be used for the very short term projection of the observation data extracted from hourly surface observations, from radar, from satellite and from lightning detection network. A prototype system has been developed to ingest hourly observations. This assimilation subsystem queries the local database at close regular intervals and extracts the relevant weather observations that are occurring at each surface observation station to update the SCRIBE weather matrices that contain the numerical forecast data. Using simple algorithms, the numerical content of the matrices is replaced with the appropriate observed values, when and where available. Further processing of the matrices up to the forecast outputs then proceeds in the regular fashion. Results from this prototype system show that 75% of the automated forecasts require updating from recent observations. Verification results will be used to assess the magnitude of the impact of ingesting the latest observation data.

2-C-4.4

TAFtools: Development of Objective TAF Guidance at MSC

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The Canadian Meteorological Centre and Recherche en prévision numérique have undertaken the TAFTools project to produce objective terminal aviation forecasts (TAF). TAFTools has three major components: the very short-range forecast (VSRF) module based on observations only (for the first 6 to 12 hours of the TAF), the short-range forecast (SRF) module based on numerical weather prediction (NWP) model outputs (for the remaining hours of the TAF) and the blending module. Only the first two modules will be discussed here. A multiple discriminant analysis (MDA) technique is used to produce a probabilistic forecast of each element by category. Results for the VSRF module indicate that ceiling and visibility probabilistic forecasts are as accurate as those obtained from a conditional climatology technique and are largely superior to both simple persistence and climatology. The probability forecasts are transformed to categorical forecasts using the unit bias method, which is designed to reproduce the observed frequency distribution of all categories.. The VSRF now produces real-time ceiling and visibility forecasts, both probabilistic and categorical, for 8 Canadian sites. Results for the SRF module, using the National Center for Atmospheric Research Re-analysis data, indicate that ceiling and visibility probabilistic forecasts are superior to the VSRF module beyond the 6 to 12-hour projection time. Selection of a specific category is done by choosing the category with the highest positive difference between the forecast probability and the climatological frequency. This method naturally allows the selection of a secondary category by

choosing the second highest difference. The SRF module currently produces probabilistic and categorical forecasts twice a day using the Global Environmental Model outputs for 8 Canadian sites. Verification results of probabilistic and categorical forecasts from both modules will be presented and discussed.

2-C-4.5

An overview: Environment Canada's Weather Forecasting Instruction for Canadian Military Weather Technicians

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In Winnipeg, Manitoba there exists an office - the Training Services Unit (TSU) Winnipeg, which consists of 4 meteorologists that are responsible on behalf of the Meteorological Service of Canada (MSC) to provide meteorological instruction including weather forecasting instruction to DND personnel directly at the Canadian Forces School of Meteorology housed at 17 Wing, Canadian Forces Base (CFB) Winnipeg. Two of the senior courses given at the School of Meteorology teach weather forecasting techniques to DND personnel, with the TSU Winnipeg meteorologists providing all the meteorological instruction on these courses. These courses are given to DND Meteorological Technicians that will be either stationed on a ship to provide weather forecasts at sea or at a fighter base to support the missions of such a base. This presentation will highlight the work that TSU Winnipeg undertakes, in particular the weather forecasting courses delivered to the Canadian Military Weather Technicians. Specifically the Weather Forecasting course syllabus, course flow and the course facilities will be presented. The challenges and the rewards of providing such a service to the Canadian Military will be one of the themes of this presentation

2-D-1.1

Seasonal forecasting activities in the Canadian CLIVAR Research Network

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The presentation will describe the Historical Forecasting Project (HFP) of the Canadian Climate Variability Research Network. The goal of the HFP is to test the mean-seasonal forecasting skill of some Canadian global numerical models under conditions that mimic an operational forecasting environment. Mean winter and mean summer forecasts have been performed for 30 years of the past with the Atmospheric General Circulation Model AGCM3 developed at the Canadian Centre for Climate Modelling and Analysis (CCCma). Some early, «quick-look» results will be presented. Plans to perform the same test with a recently developed numerical weather prediction model will be discussed. Results of seasonal forecasting experiments with a third, simpler global model will also be presented.

2-D-1.2

Improved seasonal probability forecasts

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A simple analogue of a seasonal forecast system is considered to explore the properties of probability forecasts and their accuracy measures. Probabilistic and deterministic approaches are inter-compared and the relationships between skill scores are established in the Gaussian framework. Several approaches for deriving probabilistic information from an ensemble of deterministic forecasts are discussed and their sampling properties are inter-compared. The probability estimators considered include the straightforward non-parametric estimator defined as the relative number of the ensemble members in an event category, and the parametric Gaussian estimator derived from a fitted Gaussian model. On seasonal time scales, when the internal atmospheric variations are nearly normally distributed, the parametric Gaussian approach is seen to be superior to the standard non-parametric approach. A statistical skill improvement technique is proposed for the parametric Gaussian approach and is applied to a collection of 24-member ensemble seasonal hindcasts of northern winter 700-hPa temperature (T700) and 500-hPa height (Z500). The improvement technique is moderately successful for T700 but generally fails to improve Brier skill scores of already relatively reliable raw Z500 probability forecasts.

2-D-1.3

Realization of Implicit Skill of GCM Seasonal Forecast with Singular Value Decomposition and Regression Techniques

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The singular value decomposition (SVD) technique as a multivariate linear statistical methodology for correcting distortion errors in numerical weather prediction model output is outlined. The SVD approach can lead to the optimization of forecast-analysis covariance, allowing each distorted pattern in the forecast field to be coupled with the corresponding pattern in the analysis field. The correlational relationship between the temporal variations of each pair of patterns can be used to feed a regression equation

that helps improve the prediction of the future state. This methodology is applied to a 20-winter set of seasonal ensemble hindcast of Northern Hemisphere 500-hPa geopotential height produced by the COLA (Center for Ocean-Land-Atmosphere Studies) GCM. Cross-validation approach is used to obtain uninflated skill estimates. Unlike the principal-component regression scheme developed by the authors in a previous study, this SVD scheme is not directly involved in multiple regression. Therefore the complicated predictor selection is avoided. When it is combined with a simple regression filter, the SVD scheme is capable of removing noises as well as correcting systematic errors in the structure of predicted field, leading to the realization of implicit skill of the GCM. In our COLA application, significant improvement of forecast skill is achieved in the tropical and extratropical western Pacific, East Asia, Western Canada, the tropical Atlantic, and North Africa. It is shown that remarkable skill degeneracy could occur when the temporal means (pseudo-climatology) removed from the times series vary from case to case in the cross-validation approach. This undesirable effect can be reduced by using a frozen climatology to replace the floating climatology.

2-D-1.4

Changes in the spread of the variability of the monthly mean states associated with the PNA pattern

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For a fixed sea surface temperature (SST) forcing, the atmospheric response in the extra-tropical latitudes is random and can be characterized in terms of probability distribution functions. Recent studies have shown that the atmospheric predictability tends to be lower during the cold phase of equatorial SST anomalies, or La Nina. The reason for the low predictability is partly due to the fact that the spread of the variability of the mean atmospheric state is larger during the negative phase of SST anomalies. In this study, we try to identify the possible impact of tropical SST and PNA pattern on the spread of monthly mean states in the Canadian Centre for Climate Modelling and Analysis (CCCma) GCM2. The physical mechanism of the difference is also discussed.

2-D-1.5

Simulating lower stratospheric Ozone loss in a GCM: Dynamical issues.

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Antarctic polar ozone loss was first recognised in 1985 and has been identified as being due to a combination of radiation and dynamics forming an isolated vortex. This vortex region acts as a chemical reactor during the polar springtime period, wherein anthropogenic Cl and Br are primarily responsible for efficiently destroying ozone. Even though anthropogenic halogen sources for the stratosphere appear to be decreasing it is important to know how the atmosphere will respond to changing climate conditions such as increasing CO2. Simulation of polar ozone loss for various climate scenarios requires use of GCMs which, hopefully, correctly represent the many physical, dynamical and chemical processes and interactions of the Arctic and Antarctic vortices. Results using the Canadian middle atmosphere model (CMAM) for low and high chlorine loading scenarios, together with future increased 'possible CO2' scenarios, will be presented to explore the models capability in describing the dynamical and chemical evolution of lower stratospheric polar springtime events.

2-D-1.6

Ozone change in the Middle Atmosphere

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According to measurements, the annual mean total ozone has been decreasing significantly in the past several decades [WMO, 1998]. These changes are very small (few percents per decade) but statistically significant and therefore, it is important to understand the mechanisms that drive it to predict ozone evolution in the coming decades. The Canadian Middle Atmosphere Model (CMAM) has been used in a series of sensitivity studies to investigate the model response to few mechanisms that can perturb the ozone layer.

WMO (World Meteorological Organization), Scientific Assessment of Ozone Depletion 1998,} Global Ozone Research and Monitoring Project Report No. 44, Geneva, Switzerland, 1999.

2-D-2.1

Intelligent Ocean Color Remote Sensing

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The quantification of phytoplankton, and more specifically, chlorophyll-a concentration is useful in the investigation of dynamic ecological processes. However, in coastal regions such as the Gulf of Maine, simultaneous presence of suspended sediments and dissolved organic matter in the water makes it especially difficult to discern chlorophyll-a concentration. Data has been obtained from previous research cruises in the Gulf of Maine. Many researchers consider the area to be among the most difficult in which to model chlorophyll-a concentration from remote-sensing data. Most current models are empirical in nature in that they are derived by statistical regression of radiance data versus in-situ measurements of chlorophyll-a concentration. Because of the nonlinear nature of the system, these traditional approaches have their limitations. Employing regression methods requires a priori knowledge of the nature of the nonlinear behavior, which is very complex and misunderstood in optically complex atmosphere-ocean systems such as the Gulf of Maine. The neural network models in this research differ from conventional empirical and semi-empirical models in that they are able to extract the complex input-output relationships of these environments, without a priori knowledge of the actual physical system. The neural network approach is also beneficial in that they are able to easily incorporate additional inputs that may be found to co-vary with chlorophyll-a. Neural networks are known for their remarkable ability to model systems that are represented by nonlinear characteristics, even if the data are imprecise and noisy. We have developed several neural network models such as backpropogation and radial basis function for estimating the chlorophyll-a concentration for the Gulf of Maine waters. Our preliminary experiments have shown promising results. This paper will include the results of our current investigation to further improve the results by using efficient preprocessing techniques for the data and choosing the optimum number of variables using sensitivity analysis.

2-D-2.2

The DFO Atlantic zone monitoring program

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In 1993, the Department of Fisheries and Oceans (DFO) specifically recognized that understanding the ocean - its variability, trends, and regime shifts - is fundamentally important as the basic information required for a sound management of renewable marine resources and for supporting operational use (e.g., transportation, recreation), development (e.g., hydrocarbons) and protection (various environmental protection acts) of the oceans. In that context, DFO designed the *Atlantic Zone Monitoring Program* (AZMP), which is a comprehensive ocean environment surveillance program for the Northwestern Atlantic. The basic objective of this program is to increase DFO's capacity to understand, describe, and forecast the state of the marine environment and to quantify changes in the oceans and the predator–prey relationships of marine resources. This talk presents an overview of this monitoring program, which has been implemented to fulfill the basic mandate of DFO. The fundamental elements of AZMP include: (1) *in situ* multidisciplinary monitoring of biological, chemical, and physical variables at fixed stations and along transects; (2) remote sensing of sea-surface temperature and ocean

color; (3) measurements of sea level; (4) groundfish surveys in all regions; and (5) continuous plankton recorder (CPR) lines on the Newfoundland and Scotian shelves. This program is supervised by a Steering Committee comprising representatives from MEDS (Ottawa) and the different DFO regions (Maritimes, Newfoundland, and Quebec), and is supported by three Sub-Committees dealing with (1) field sampling coordination and standardized sampling protocols, (2) data management coordination, and (3) data analysis and interpretation, which is a critical component for ensuring that AZMP will continue to produce meaningful results and data products for the different internal and external clients.

2-D-2.3

Monitoring Cryospheric Processes in Canada with Spaceborne Scatterometer Data

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Recent investigations have demonstrated the potential of scatterometer data acquired at Ku-band (25-km resolution) and C-band (50-km resolution) for monitoring the freeze/thaw status forest and tundra surfaces in Alaska and Siberia. Although the scatterometer data were originally intended for determining wind speed over the oceans, these data offer a great potential for monitoring cryospheric pr ocesses from regional to hemispheric scales. Scatterometers, which have a much wider field of view than SAR sensors, can provide a global picture of the land surface every few days with ERS-1 and -2, and on a daily basis with seawinds on Quikscat. This data can therefore provide a week-to-week, month-to-month and year-to-year perspective of how land surfaces are changing. The coarser spatial resolution data are also of particular interest for climate modelling and for understanding the fluxes between the land surface and the atmosphere. The primary objective of this study was to investigate the potential of scatterometer data from the seawinds instrument onboard Quikscat for monitoring the Canadian cryosphere. In this paper, we will present how (including computer animations) we are using Quikscat data to monitor cryospheric processes over various regions of Canada (i.e. frozen/thawed state of various surface types, snow accumulation/melt and episodic thaw/refreezing events, and lake ice formation and decay).

2-D-2.4

Penman Evaporation Revisited - a Practical Alternative to Pan Evaporation

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In the fall of 2001, Water Survey of Canada staff requested assistance in implementing the Penman (1948) evaporation formula. In practice, pan-derived lake evaporation has been used historically to calculate water allocations for apportionment on international streams flowing between Canada and the United States. However, evaporation pans require manual servicing on a daily basis and present special operational challenges in water-short regions such as southern Alberta and southwest Saskatchewan. Automated evaporation pans may provide an alternative to daily servicing but other difficulties remain. As a test of the Penman approach, net radiation data together with daily temperature, dew point and wind speed data for 1983 from Lethbridge were utilized. The Meyer equation expressed in a daily form was substituted for the original bulk aerodynamic expression in Penman's formula. The daily Penman evaporation was compared with the daily pan-derived lake evaporation through the open water season. While the magnitude of the daily Penman evaporation was less than the pan-derived lake evaporation, the daily fluctuations were well emulated throughout the open water season. An assessment of the years from 1974 to 1988 at Lethbridge confirmed the initial results for 1983. The approach was then applied to 15 other sites across Canada where both net radiation and pan evaporation data were available. Although the results were generally not quite as good as those found on the Prairies, the Penman equation was successful in emulating the pan-derived lake evaporation on a daily basis from the high Arctic to the Maritimes. The methodology was subsequently tested at Onefour, Alberta for 2001, where all the necessary parameters are measured, including automated pan evaporation. The results suggest that the Penman formula could be used operationally for apportionment purposes.

2-D-2.5

Hydroacoustics: a set of tools to study aquatic northern ecosystems

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Passive and active hydroacoustic instrumentation and methods have evolved rapidly in the last decades as result of the technological boom in computer and electronics. These methods have become the most penetrating and efficient tools presently available for looking through the ocean over long ranges with a high resolution. Scientific echosounders use several acoustic frequencies and beams to literally continuously tomography the ocean along tracks surveyed by research ships and get real-time information on the distribution, composition and abundance of plankton and fish over the whole water column. Bottom imagery and substrate composition can be achieved with multibeam sonars and detailed analysis of the bottom echoes. Hydrophone arrays can be used to continuously localise vocalising animals, such as marine mammals, over large basins and be informed on the frequency of occurrence of these apex predators in their three-dimensional habitat, to localise and better understand the hot spots and identify the critical areas or periods. One notable advantage of these passive and active acoustic systems is that recording can be done remotely, with or without real-time data transmission, which is very desirable for distant northern environments that cannot be frequently visited. Another important advantage of these modern technologies is that data processing can be automated and hence be done at relatively very low cost.

2-D-2.6

Shipborne thermosalinographs monitoring near-surface temperature and salinity in the gulf of St. Lawrence

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Shipborne thermosalinographs have been deployed since December 1999 on commercial shipping routes in the gulf of St. Lawrence through a collaborative effort between industry, the Canadian Ice Service - EC, the Canadian Coast Guard and the Ocean Sciences Branch (both DFO – Quebec region). This deployment is funded through a PERD (*) project to reduce CO2 emission by providing better routing to ships using as support a real-time ocean model of the Gulf of St. Lawrence fed by the thermosalinograph data.

Ships currently instrumented are the Cicero that runs between Montreal and St-John's, the Nordik Express between Rimouski and Blanc-Sablon on the lower North shore, the

C.T.M.A. Voyageur between Montreal and the Magdalen Islands, as well as the C.C.G.S. Martha L. Black.

The data acquired thus far are summarized into descriptive data analyses that illustrate how the data are used as a monitoring tool for near-surface conditions. For example, the temperature and salinity along shipping routes are summarized over each full year on single figures, and interannual differences are displayed in the same manner. These data are displayed on the St. Lawrence Observatory web site at www.osl.gc.ca.

Shipborne thermosalinographs are a cost-effective monitoring tool because they sample a large percentage of the time and because manpower is not required for sampling but only to maintain the equipment.

(*) Program on Energy Research and Development; POL : Optimization of the energy efficiency of transportation systems. Project: The St Lawrence
routing management support model.

2-D-3.1

Simulation and Detection of the Arctic Climate Forcing due to Anthropogenic Aerosols

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The Arctic is influenced by human activities in several ways. In particular, long-range transport of pollutants alters the composition of natural aerosols. Two leading processes are investigated for their potential climatic effect at high latitudes. In parallel, simulation and observation have improved greatly in recent years. The paper will discuss the following aspects. During summer, extensive low-level clouds controls surface radiation. Excess solar energy is primarily used to melt snow and ice at near freezing temperatures. Natural aerosol (soil, sea salt and DMS derived sulphate) controls the water cycle and cloud albedo. SOLAS is one Canadian project linking the ocean emission to low cloud climatology. The addition of anthropogenic sulphate is significant for the regional climate.

2-D-3.2

Aerosol-Cloud Interactions: A Sensitivity Study with a Single Column Model and the Mesoscale Compressible Community (MC2) Model

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The indirect forcing due to anthropogenic aerosols is one of the most uncertain among the possible forcings of climate. This is particularly due to uncertainties in aerosol concentrations and properties, but much of the uncertainty is due to the parameterizations of cloud microphysical processes in climate models. An important component of the cloud parameterizations is the prediction of cloud droplet number concentration (CDNC) in a physically based manner. The observed wide variations in CDNC can be expected to produce large differences in precipitation efficiency and in the optical properties of clouds. Although such variations in CDNC can be prescribed from observations, there is currently a great interest in predicting CDNC because they are influenced by anthropogenic aerosol.

In this study, we simulate at high resolution the physical processes that govern aerosol-cloud interactions in summertime stratus clouds that occurred over the North Atlantic. We use the Mesoscale Compressible Community (MC2) model and a Single Column Model (SCM), both of which employ explicit treatment of clouds. To handle the link between anthropogenic aerosol concentrations and CDNC we utilize an explicit nucleation model, which depends on the updraft velocity, the total aerosol number and mass concentrations (Abdul-Razzak et al., 1998). We compare results from the numerical simulations with in-situ aircraft observations made during 1995 Canadian Radiation, Cloud and Aerosol Experiment (RACE). We then examine the response of modeled cloud properties to different representations of aerosol by, first, prescribing the aerosol number concentration and, then, allowing it to be modified by the cloud microphysical processes. Finally, we draw conclusions on what details of aerosol-cloud interactions need to be incorporated for accurate modeling of the indirect aerosol effect.

Abdul-Razzak, H., S. J. Ghan, and C. Rivera-Caprio, 1998: A Parameterization of Aerosol Activation, 1. Single Aerosol Type. J. Geophys. Res., Vol. 103, No. D6, pp. 6123-6131.

2-D-3.3

The sensitivity of precipitation to circulation details

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This investigation is aimed to clarify why small changes in the details of synoptic airflow can result in significant variation of rainfall amounts associated with Rocky Mountain lee cyclogenesis. A base case and the best time-coherent analog to that case were analysed to determine the mechanisms responsible for the differences in precipitation amounts. The PSU/NCAR MM5 model was used to obtain a high-resolution model data set that provides dynamic coupling among the various fields. Differences in moisture source origins of parcels arriving within the precipitation region accounted for the rainfall variation between the base case and analog during the first day. Coupling of an upper and lower-level jet streak allowed for near-surface lifting to occur in the base case during the second day. The jet streak coupling did not occur in the analog and reduced near-surface lifting relative to the base case. A non hydrostatic, axisymmetric cloud model with large-scale convergent forcing was used to perform selected experiments to assess the triggering of convection in a controlled setting. The experiments indicated that the differences in the integrated convergence at cloud base (rather than differences in thermodynamic profiles) were certain determining the stronger precipitation in the base case.

2-D-3.4

Expanding and enhancing the quality control system for solar radiation data processed by the MSC

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The Canadian solar radiation network, established in the mid-1960's, presently consists of over 40 stations distributed throughout the country. From 1980 onwards, the size of the network has been shrinking and resources for inspection, maintenance and quality control have been cut back. Until the mid-1990's, Canadian solar radiation data was subjected to vigorous human interactive quality control procedures. At present, the quality control of solar radiation data is inadequately resourced and a backlog exists. To increase the efficiency in which solar radiation data are processed, automated procedures have been developed to reduce the reliance on human data handling and interactive quality control. Network modernization is in process and it is expected that data will be transmitted automatically in near real-time mode. The future network consists of 50 RF1 sensors at RCS stations and CORE stations with a full set of radiation sensors. In anticipation of the receipt of digital data in near real-time, the MSC developed automated quality assurance and control procedures to facilitate the archiving of solar radiation data in a more timely fashion. These algorithms will assist in identifying potentially erroneous data and direct a quality control technician to the suspect period for visual inspection and detailed analysis. This will greatly accelerate the processing and quality control of backlogged data. Daily thumbnail graphs and error reports will be generated for quick inspection by a trained technician. From the visual analysis, subsequent interactive quality control can be efficiently targeted. The daily graphs can also be posted on the MSC Intranet and made available to regional offices so they can monitor the performance of their stations and instruments. The development of the data

processing and quality control systems will make solar radiation data more readily accessible to clients and ultimately improve the quality of the measurements since errors due to maintenance issues will be detected and corrected on the order of days, rather than weeks or months. The software is currently being developed and a display of the prototype will be presented.

2-D-3.5

Effect of aerosol microphysical properties on wintertime low cloud formation in the Arctic

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A mixed-phase cloud microphysics scheme (Girard and Blanchet, 2001) is used to investigate clear sky precipitation and ice fog in the Arctic during winter. The microphysics scheme takes into an account the aerosol size distribution and microphysical properties to determine cloud microphysical processes. The microphysics scheme has been implemented into the Northern Aerosol Regional Climate Model (NARCM). NARCM is a limited-area non-hydrostatic model with physical parameterization and a dynamic size-distributed aerosol scheme CAM (Canadian Aerosol Module). It simulates aerosol explicitly with 12 size bins from 0.005 to 20.48 mm (Gong et al. 2002). The aerosol module CAM (Canadian Aerosol Module) in NARCM is a size-segregated multi-component algorithm that treats five major types of aerosols: sea-salt, sulphate, black carbon, organic carbon and soil dust. It includes major aerosol processes in the atmosphere: production, growth, coagulation, nucleation, condensation, dry deposition, below-cloud scavenging, activation, a cloud module with explicit microphysical processes to treat aerosol-cloud interactions and chemical transformation of sulphur species in clear air and in clouds. Each of these aerosol processes is strongly dependent on particle size, thus requiring an explicit representation of the size distribution. In this paper, we show the performance of this scheme for both 1D and 3D simulations. 1D simulations are performed at Alert from 1991-1994 using aerosol measurements and aerological soundings to drive the model. The sensitivity of cloud formation (clear sky precipitation and ice fog) to aerosol microphysical properties will be shown for this case. The performance of the microphysics scheme is also evaluated with the 3D-model using precipitation observation for January 1998 over the Arctic..

2-D-4.1

Modelling of a renewal event in the Saguenay Fjord

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During spring and summer 1998, observations of water level, velocity, temperature and salinity were made in the Saguenay Fjord. Density profiles and time series showed that an episode of deep water renewal occurred between mid-July and the end of August. Subtidal velocities could be accordingly explained. This was the first observation of deep water renewal in the inner basin of the Saguenay. A three-dimensional numerical model of the fjord has been used to produce 30-day simulations of the velocity and density fields in the fjord in times of renewal. The model takes into account the combined influence of the tides, freshwater runoff and changes in density in the adjacent St. Lawrence Estuary. Observed series drive the model and simultaneously observed series of density and velocity could be used for comparisons. The model uses a realistic initial density field built from hydrographic data sampled soon after the beginning of the renewal. Mixing is intense in the outer basin and several parameterisations of the kinematic eddy diffusivity failed to produce enough mixing. We resorted to an ad hoc parameterisation that uses a simple Ri-dependent formulation to which one adds a time-dependent supplement in an arbitrary region near the boundary. The model reproduces successfully much of the tidal and subtidal variations in density and velocity. One can then follow the propagation of the new and expelled waters, and examine the details of the subtidal changes in density and velocity during a deep water renewal event.

2-D-4.2

A coupled atmospheric-hydrological modeling study of the 1996 Ha! Ha! River basin flash flood in Québec, Canada

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We use a high-resolution regional atmospheric model coupled to a hydrological model, and an off-line routing module to simulate a hydrograph during the 1996 July flash flood that occurred in the Saguenay region of eastern Québec. The hydrograph is at the outlet of the Ha! Ha! Lake in the Ha! Ha! River basin. The former has a drainage area of 250 km2 and is covered by 6 model grid squares; the precipitation at these grid squares compare well with observations at the nearest available rain gauge located 20 km south of the basin. The hydrological model is a modified version of a land surface scheme which consists of three soil layers, and the routing module is based on the geomorphological unit hydrograph. The simulated hydrograph is compared with another reconstructed hydrograph in the published literature.

2-D-4.3

A numerical study of the 1996 Saguenay flood: Effect of assimilation of precipitation data on quantitative precipitation forecast

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The purpose of this paper is to explore the effect of assimilation of rain gauge data on extending the predictability of precipitation as part of the Canadian Weather Research Program. The case under study is the 1996 Saguenay flood storm over Quebec, Canada which caused over one billion dollars in damage. The 48-hour operational forecast initialized with the Canadian Meteorological Centre (CMC) analysis at 0000 UTC 19 July failed to predict the intensity and spatial distribution of precipitation. The QPF improved when the model was initialized 12 hours later, indicating possible initial condition errors at 0000 UTC. For this study, we used the Canadian MC2 model with a resolution of 35 km. Before assimilating rain gauge data, we first explored the effect of different convection schemes and the errors at the lateral boundaries. It was found that when the model is initialized at 0000 UTC 19 July, the Kain-Fritsch convection scheme yields smaller RMS and bias errors in all meteorological fields at 1200 UTC relative to the Kuo scheme. However, there is excessive moisture between 1000 and 700 hPa compared to the CMC analysis. When the fields at the lateral boundaries are replaced by filtered fields where all wavelengths below 600 km are removed using a technique proposed by Ooyama (1987), there was little change in the domain-averaged bias and RMS error at 1200 UTC. Hourly precipitation data from rain gauges located over the continental United States are then assimilated using a one-dimensional variational data assimilation scheme with Kain-Fritsch deep convective parameterization to generate a new initial condition at 0000 UTC. The 12-h forecast valid at 1200 UTC indicated a reduction in the domain averaged low-level (950-850 hPa) moisture content, thereby reducing the moist bias evident in the runs initialized with the CMC analysis. Results on the QPF scores (e.g. threat and bias) using the new initial conditions for a 60 h forecast will be reported.

2-D-4.4

The Efficiency of a Catastrophic Capping Layer Deposited in the Saguenay Fjord During the Flood of 1996: Geotechnical aspects

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In July 1996, an important flood took place in the Saguenay region. This disaster was marked by the catastrophic swelling of some tributary rivers of the Saguenay Fjord, which eroded and deposited about 20 million tons of sediment in the upstream section of the fjord. This flood layer, identified as turbidite deposit with a variable thickness ranging from 10 cm to 7 m, not only had bad consequences. The new sediments have recovered the underlying contaminated sediments with a clean layer of sediments over a large surface now acting as a capping layer. This event provided a unique opportunity for a group of engineers and scientists to investigate the performance of the flood deposit as a physical and/or biogeochemical barrier to the migration of contaminants associated with the underlying, indigenous sediments up to the new water/sediment interface. Depending on the particular expertise of the investigators involved in the project, this flood layer was distinguished from the indigenous sediments by its geotechnical properties (weak consistency and low resistance), its high water content, the absence of benthic organisms, or the presence of inherited geochemical components. This paper presents some results

of the geological and geotechnical aspects of the performance and integrity of the capping layer. The results indicate that consolidation of the flood and pre-flood sediments was completed in the first year following the deluge, and also, that the consolidation behaviour is influenced by the bioturbation. In addition, it is shown that the multibeam sonar can be a useful tool to evaluate the geometry and to study the morphology of the capping layer. It is also useful to monitor the evolution of some properties of the new layer, such as, water content and density. Up to now, the layer is effective to isolate the contaminants, but in long-term, it seems that slope instability related processes might affect the integrity of this flood layer.

2-D-4.5

Controlling factors for contaminant transport through a sediment cap: the case of the flood sediments of the Saguenay Fjord

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In July 1996, two days of intense rainfall caused severe flooding in the Saguenay region and led to the discharge by rivers of several million cubic meters of clean sediments to the Fjord. These clean sediments represent a natural barrier, or capping-layer, separating the underlying sediment, contaminated with heavy metals and PAHs, from the water column. To evaluate the long-term effectiveness of the capping layer, a numerical model has been developed for the simulation of the one-dimensional vertical migration of contaminant through a sediment cap. The model considers the physical, chemical and biological factors affecting the fate of a dissolved contaminant in the sediment. These factors include advection, diffusion, chemical reactions and the effect of tube-building and bio-irrigating worms. The numerical model is composed of two transport equations describing the contaminant migration in the sediment and in the bio-irrigated burrows. The equations are coupled via a mass-transfer term representing the exchange of contaminant between the pore-water and the burrow-water. Since 1996 the flood sediments of the Saguenay Fjord have been extensively studied in field and laboratory by different research groups. Sediments from several sampling stations have been characterized for their biological, geotechnical, and geochemical properties. The collected data served to calibrate the numerical model and perform a detailed sensitivity analysis. The results of the sensitivity analysis illustrate the significant effect of the bio-irrigation parameters on contaminant migration through the layer, assessing at the same time the impact of uncertainty in the knowledge of these parameters on model predictions.

2-D-4.6

Analyse Qualitative et Quantitative de la Bioturbation dans la Baie des Ha! Ha!, Fjord du Saguenay (Québec).

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En juillet 1996, une crue éclair a provoqué un apport exceptionnel de sédiments dans la baie des Ha! Ha! (Québec) et a eu pour conséquence d'éliminer, en partie ou en totalité, la faune benthique en place. Ces sédiments se sont déposés dans la baie sous la forme d'une couche d'épaisseur décroissante depuis la tête de la baie (station 2) vers son

embouchure (station 13). Pelletier et al. (1999) rapportent une recolonisation rapide de la nouvelle couche sédimentaire par les annélides polychètes. Cependant, malgré la recolonisation, la population d'annélides polychètes est relativement instable et des différences sont observées entre les populations des quatre stations échantillonnées. L'objectif de cette étude consiste à étudier les variations de la faune et l'influence de l'activité biologique sur la colonne sédimentaire en fonction d'un gradient de perturbation et d'autre part de développer une nouvelle méthode d'étude des structures biogènes en utilisant la tomodensitométrie axiale. Cette méthode s'est révélée très efficace pour différencier l'influence de l'activité des organismes de l'influence des paramètres sédimentologiques tels que les $CaCO_3$, la taille des particules et la porosité. L'utilisation de la tomodensitométrie a également permis d'étudier la relation entre l'importance du volume des structures biogènes (en %), reflétant l'activité biologique, et les valeurs IT, en fonction de la profondeur. Cette méthode s'est également révélée très précise pour quantifier l'espace créé par les structures biogènes dans la colonne sédimentaire afin d'observer si les différences d'occupation des sédiments (exprimées en volume de structures biogènes) sont reflétées par des différences d'abondance ou de composition (en espèce ou en groupe trophique). Les résultats obtenus montrent des différences entre la station 2, en terme d'espèce et en terme de groupe trophique, et les stations 5, 9 et 13.

3-A-1

New developments in the Scientific Committee on Oceanic Research

Nouveaux développements au comité scientifique sur la recherche océanographique

Björn Sunby

3-A-2

New developments at the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS)

Gordon McBean
Chair, Board of Trustees Canadian Foundation for Climate and Atmospheric Sciences, Ottawa

Over the last year the Foundation has intensified its activities to address Canadian priorities in climate, weather and marine environmental research. Within two years, the Foundation has committed almost $30 million to university-based research initiatives and networks, most of which in the last year. These funds have been more than matched through partnerships with federal and provincial departments and agencies, universities and the private sector. CFCAS has also played a key role in sustaining and expanding the pool of skilled personnel in atmospheric and oceanic sciences.

Recent progress will be reviewed and challenges addressed: the need for sustained support; for better coordination of activities involving different players; for renewal of research infrastructure; and for unequivocal evidence that Foundation investments are achieving results. Examples of scientific leadership will be highlighted and information provided on how Foundation projects are advancing Canada's climate imperatives and supporting policies that benefit all Canadians.

Du nouveau à la Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA)

L'an dernier, la Fondation a intensifié ses activités en réponse à l'ordre des priorités canadiennes que sont les changements climatiques, les conditions météorologiques extrêmes et la recherche environnementale marine. En l'espace de deux ans, la Fondation a engagé presque 30 millions de dollars au financement des projets et des réseaux de recherche universitaires, le plus gros de cet investissement l'an dernier. Et plus que l'équivalent a été avancé en contrepartie par les ministères et organismes fédéraux et provinciaux, les universités et le secteur privé dans le cadre de partenariats. La FCSCA a joué également un rôle primordial dans le maintien et l'expansion du bassin de personnes qualifiées en sciences atmosphériques et océaniques.

On fera le point sur les progrès récents et les autres dossiers feront l'objet d'un examen également, à savoir la nécessité de bonifier l'aide accordée, d'assurer une meilleure coordination des activités entre les différents intervenants, de renouveler l'infrastructure de la recherche et de faire état des preuves irréfutables du succès des investissements de la Fondation. On mettra en lumière les exemples de leadership scientifique et on expliquera comment les projets de la Fondation vont dans le sens du règlement des questions climatiques pressantes au Canada et des politiques favorables à tous les Canadiens.

3-A-3

The impact of the stratosphere on North Atlantic climate variability

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3-B-1.1

Les changements climatiques: le défi du siècle / Climate change: Challenge of the century

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Les changements climatiques préoccupent de plus en plus le public en général et plus particulièrement, les gouvernements et le secteur privé. Le bon accord entre la modélisation, les données historiques et le comportement du climat confirme que le forçage anthropique a déjà et aura de plus en plus d'impacts sur les activités humaines. Les changements climatiques sont fondamentalement un problème énergétique, engendré par l'utilisation des combustibles fossiles pour la croissance économique et sociale. Les projections basées sur la consommation "habituelle" d'hydrocarbures nous mènerait à "4 fois CO2" avant la fin du siècle. Atténuer les effets des changements climatiques requièrent une approche structurée. Des progrès importants seront requis pour réduire les émissions à un niveau stable de 2 fois la concentration des gaz à effets de serre déjà existants avant la période industrielle. Simultanément, des efforts majeurs sont requis pour évaluer l'impact et proposer des scénarios afin d'atténuer les effets régionaux ou prendre avantage des opportunités de développement ici ou ailleurs pour un environnement d'au moins deux fois CO2. Les scénarios climatiques seront présentés en insistant sur les scénarios de développement socio-économique consistant avec le climat et en mettant l'emphase sur le contexte canadien. Ouranos, le consortium régional créé récemment pour faire face aux changements climatiques sera brièvement présenté.

"Climate change" is getting increasingly more attention from the general public at large, and both government and private stakeholders in particular. Good agreement between modeling, climate data and current behavior has brought confidence that anthropogenic forcings already have and will increasingly have a major impacts on human activities. Climate change is basically an energy problem, borned from reliance on fossil fuels for economic growth and social development. Current assessment indicates that "business" as usual will lead to "4 times CO2" before the end of the century. Climate change mitigation requires an integrated approach. Major advances will be required to bring emissions down to a stabilized level equal to 2 times de green-house-gas concentration that was present before the industrial phase. Simultaneously, major efforts are required to assess impacts and propose adaptation scenarios to mitigate regional effects or take advantage of development opportunities here and abroad. This presentation will assess current and foreseeable climate scenarios, describing at the same time past and future human development scenarios consistent with the climate. Emphasis will be on the Canadian context.
Ouranos, a regional consortium being set up to cope with climate change issues will also be briefly described.

3-B-1.2

Canadian Disasters - An Historical Survey

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The major Canadian disasters from the 1500s to date are identified by cause and type. General disaster criteria are defined. Twenty or more deaths occurring at one time is the primary criterion. The other principal criterion is to include events which have occurred within Canada, and Newfoundland before 1949, and offshore inside the 200-mile

economic zone. Events such as wars, epidemics and battles between natives and European settlers during colonization have been excluded. These criteria limit the events which are discussed to a manageable number. The results of an expanded literature search are presented and a brief description of some of the disasters is given. An historical perspective is discussed with a view to illustrating the disasters which were common in early Canadian history, and those which have occurred in modern times. Conclusions are drawn as to which types of natural and man-made disasters are likely to occur in Canada in the future. In the ten years since original publication the database has doubled in size.
The updated version of the paper is published on the World Wide Web at: http://www.ncf.ca/~jonesb/DisasterPaper/disasterpaper.html
KEY WORDS: disasters, Canadian disasters, weather-related disasters

3-B-1.3

Towards regional scale climate change detection

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Using a spatial-temporal optimal detection technique, we assess the extent to which climate change in the latter half of the 20th century as simulated by Canadian coupled GCMs may be detected in observations of near surface temperatures. Our analysis is conducted in 6 spatial domains: 1) the entire globe; 2) the Northern Hemisphere; and four regions in the Northern Hemispheric mid-latitudes covering 30N-70N, including 3) the Eurasia continent; 4) the North American continent; 5) land only and 6) the entire 30N-70N belt. The hypothesis that observed changes during the past 50-years are entirely due to internal climate variability is rejected at a high level of statistical significance for annual mean temperatures for all domains. Climate change is also detected in seasonal mean temperatures for the past 50-years, with signals detected for more seasons in larger domains. The model simulated temperature trend attributable to the combined effects of greenhouse gases and direct sulphate aerosol forcing is, in general, similar to (though slightly larger than) the observed warming. However, the 1950-1999 model simulated trend for the Eurasian continent is considerably smaller than observed, suggesting that winter warming in recent decades in this continent may be affected by factors other than greenhouse gas and direct suphlate forcing.

3-B-1.4

Climate Scenarios for Quebec

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In the context of climate change, means are necessary to evaluate the range of possible impacts with respect to variations in greenhouse gas and sulphur emissions as well as demographic and economic developments. Climate change scenarios are based on the evaluation and inclusion of these parameters with results from GCM's (Global Climate Models) outputs and represent possible alternatives or story-lines on how the climate may change within the next century. Using the Intergovernmental Panel on Climate Change « Guidelines on the Use of Scenario Data for Climate Impact and Adaptation Assessment », climate scenarios based on GCMs outputs and LARS-WG Stochastic Weather Generator were developed for areas within the province of Quebec. Analysis of the climate projections (IPCC Data Distribution Centre) was performed using the results of the different climate change integrations forced with IS92a and SRES (A1, A2, B1 and B2)

emission scenarios. Results for the Saint-Lawrence River area indicate that this region could experience increases in temperature in the order of 3 to 8 °C as a function of period of the year and level of emission forcing. Expected changes in climate and particularly in temperature distributions may thus produce significant impacts on the environment, ecosystems and society. The inclusion of climate scenarios in impact studies should thus be of prime interest for the evaluation of the range and extent of possible changes for such sectors such as agriculture, state of the Saint-Lawrence and other ecosystems as well as human infrastructures.

3-B-1.5

Impact of sea level rise on beaches and acquifer of Kavarathi an atoll of Lakshadweep Archipelago - India

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Lakshadweep islands situated off the Kerala coast are made up of coral reefs of Holocene age. It is stated that in the chagos-maldives-Laccadives ridge several volcanos and lava flows, split down the centre line by deep clefts with steep slopes. Kavarathi atoll is one of the prime atolls of this archipelago, located in the Lakshadweep sea at 404 KM from Kerala coast (Cochin). Geographically it is between 10 32 to 10 35 N latitude and 72 37 to 72 39 longitude. The total length of the island is 4.8 km and maximum width is 1.50 km. It is oriented along a north south axis with the coral reefs and lagoon on the west and the island to the east. the length of the lagoon is 4.5 km, average width about 0.8 km. and depth 3.00 M. The soil being very porous and devoid of humus and do not retain any moisture. It is reported that there are 290 species of plants out of which 230 are angiosperms also fifty six species of fresh and sea water algae. Beach stability, coastal elevations from mean sea level, fresh water aquifer and the structures and other establishments located near the beach of Kavarathi atoll were surveyed and studied. The very high waves (6M) during south west monsoon have eroded the reef into coarse and fine sands and latter transported and deposited on the eastern side behind coral boulders and pebbles. The western side of Kavarathi have sandy beach enclosed by crystal clear lagoon water and the astern side the beach is a stormy beach covered with coral rocks and boulders. Beach erosion is a regular phenomena at many locations of the Kavarathi coast. Three segments of severely eroded beaches and one stable beach were identified for beach profile study. The chart datum is considered as the Mean Sea Level for topographic measurements. The ground elevations were measured using the dumpy level at an interval of 30 M in the longitudinal direction. The ground water characteristics of atoll of Kavarathi was observed during monsoon, pre monsoon and post monsoon regimes. The fragile nature of fresh water aquifer was delineated and examined in the light of the sea level rise. The shore line recession is studied using Bruun's rule.

3-B-2.1

Tides, long period slopes and flows in the Arctic Archipelago

David Greenberg

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As part of Canada's commitment to the international Global Ocean Observing System (GOOS), permanent tide gauges are being installed in the Arctic. A primary goal is to obtain high quality, levelled sea surface data to look at long term changes in sea level and slopes that would indicate changes in transport patterns. This presentation will look at the progress in using a three-dimensional barotropic finite-element model to help in the analysis of the data. The model is used to examine how the complex tides change with seasonal ice cover, how the transport varies with the period of the sea level difference between the Arctic and the Atlantic, and how the sea level signal of the Arctic Ocean is transmitted through the Archipelago.

3-B-2.2

Ramifications of Interannual Variation of the Springtime Climate on the Energy Budget of Sea Ice in the Canadian Arctic Archipelago

Tim Papakyrikaou[1], John Hanesiak[1], Martin Fortier[1], David Barber[1], Ellsworth LeDrew[2]

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Over the years between 1992 and 1995 a detailed field investigation was undertaken in the central Canadian Arctic to examine the interactions among the surface heat budget of seasonal sea ice, surface properties and climate for a fully coupled ocean-sea ice-atmosphere system. Previous work has commented on the variability in the spring season climate in the central Canadian Islands over this period. The spring of 1992 was extremely cold, being the second coldest year on record at Resolute. The spring seasons of 1993 and 1994, on the other hand, were unusually warm and, in fact, were the fourth and sixth warmest spring seasons on record, respectively. The spring of 1995 was also unseasonably warm. In both 1994 and 1995, meteorological events lead to an anomalously rapid removal of the snow cover. A rain event during May of 1994 was the earliest on record, whereas the heat wave of early July 1995 (T>10ºC) was unprecedented in the 51 year record (1950-2001). Not surprisingly, we observed a high degree of interannual variation in the surface energy budget in response to varying environmental forcing. In this presentation, the springtime energy budget is described over spring seasons and patterns of association are established between the components of the energy budget and characteristics of the surface and atmosphere using a data set that reflects an immense range in springtime atmospheric conditions. Within these patterns we are able to identify a suite of feedback mechanisms between the surface and atmosphere that involve the surface energy budget. The implications of our results are discussed in relationship to under ice biological productivity in light of observed and projected warming in the Canadian Arctic Archipelago.

3-B-2.3

Application of satellite altimetry observations to studies of flow in Bering and Chukchi Seas and through Bering Strait

Josef Cherniawsky, William Crawford and Eddy Carmack

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We investigate the use of oceanographic observations combined with satellite altimetry data (TOPEX/POSEIDON and ERS-2) to investigate changes in the rate of flow of fresh

water and heat from the North Pacific to the Arctic Ocean. Altimetry observations provide global coverage unimpeded by cloud cover, thereby providing a method to determine links between flow through Bering Strait and oceanographic features far from this strait. Present models of sea ice in the Arctic lack information on this transport of heat and fresh water, and will be greatly improved with this information. We present results of a study to determine the signals and background noise levels in altimetry observations near Bering Strait. TOPEX/POSEIDON (T/P) tracks converge at this strait, providing much better coverage in space than is available in T/P observations in other regions of the ocean. This coverage will help resolve sea level changes due to local storms that drive strong flows through this strait. ERS-2 observations extend farther north of T/P tracks, and are expected to provide useful information on ocean conditions during ice-free times.

3-B-2.4

Baroclinic simulations of the circulation in the Canadian Arctic Archipelago

Nicolai Kliem

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A linear diagnostic numerical ocean model is used to study the freshwater fluxes through the Canadian Arctic Archipelago. The data coverage is relatively low in this area. Based on existing data from different datasets climatological temperature and salinity fields are constructed and used as forcing fields for the numerical model. Other forcing includes tidal elevation used for boundary condition. Work is in progress to apply a nonlinear prognostic model, and eventual atmospheric forcing and sea ice will be included in the simulations. Focus in this presentation is the effects of the baroclinic forcing on the circulation, and the nonlinear effects included in the prognostic simulations. The simulated tides, and the flow through a number of sections will be compared with existing data.

3-B-2.5

General Circulation of the Pan Arctic-North Atlantic Ocean Using A Coupled Ice-Ocean GCM.

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A coupled ice-ocean model (CIOM) was applied to investigate the general circulation of the pan Arctic-North Atlantic Ocean (PANAO). The seasonal cycle of the ice-ocean system was studied under daily wind and other atmospheric forcings using the NCEP/NCAR reanalysis data, restored to the surface monthly climatological temperature and salinity (NODC data). The simulated total transport of the Labrador Sea is consistent with historical estimates. The western North Atlantic is dominated by the cyclonic Labrador Current system, while the eastern North Atlantic is dominated by the anticyclonic gyres. Greenland Basin has a cyclonic gyre, while the Norwegian Basin also has a cyclonic gyre. In Fram Strait, the model simulated an outflow of Arctic surface water from the Greenland side and inflow of the North Atlantic Water from the eastern side. The simulated temperature and salinity in Fram Strait indicate the intrusion of the Atlantic Water and the outflow of the Arctic surface water. In the Arctic Basin, the simulated total transport is cyclonic in both the Eurasian Basin and the Canadian Basin although the surface ocean current is anticyclonic. The model results are compared to

observed sea-ice areas, thickness, heat content, freshwater thickness, and circulation transport in the Labrador Sea.

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3-B-3.1

Estimating ground-air exchange on the micro-meteorological scale

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As a simple alternative to direct measurements, it may sometimes be useful to diagnose the strength (Q) of a finite surface area source of a trace gas, from nearby measurement(s) of concentration (C). This is sometimes called "inverse dispersion", and requires the use of a suitable dispersion model, which must be provided measurements of the atmospheric state: at a minimum, the friction velocity, Obukhov length, roughness length, and mean wind direction. A particularly flexible approach is to determine Q from C by calculating an ensemble of (turbulent) backward trajectories, and recording trajectory touchdowns on the source. To test the accuracy of this backwards Lagrangian stochastic ("bLS") method, we performed a series of experiments: methane was released at a known rate from a 6m x 6m source on ground, and detected by line-averaging laser concentration sensors nearby. The talk will cover cases where the source was on open terrain (undisturbed winds), and cases where the source lay within a windbreak. Our results suggest that, provided the concentration detector is "far enough" from the region of disturbed winds, "naive" inverse dispersion, i.e. source inference using a model that neglects disturbance to the wind (trees, fences, etc.), may give a useful approximate estimate of source strength, i.e. an estimate whose error is no more than about 25%, for one hour average concentrations.

3-B-3.2

Role of Soil Freezing in Boreal Climate and its Future Evolution

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The impact of soil freezing on boreal climate and its future evolution is examined using climate models. The thermal effect of soil freezing on climate change is first analysed with four GCM simulations, performed with the french model LMDz, which has been adapted to polar climates. Runs were carried out both with and without taking into account for soil freezing. In each case, two runs correspond to modern climate and two others represent the end of the 21st century. Present-Day and Future simulations display some changes aspects of the surface temperature, precipitation, and soil humidity when taking into account for soil freezing. Two soil mechanisms (a thermal effect of frozen ground and an hydrological effect) are identified and strongly constrain surface temperatures in boreal regions. We will also specifically discuss how freezing in a GCM can modify regionally the simulated response of the model to anthropogenic climate forcing. Different impacts of soil freezing on climate change in North America and Siberia are observed, two regions where snow cover has a substential impact on freezing and thawing processes. We will then expose possible important feedbacks involving soil freezing that may be considered when predicting climate change at high latitudes. Secondly, we have examined the results provided by the new ECMWF reanalyses project, ERA 40, running with an improved soil scheme. This study covers the period 1987-2001 (ERA 40 is still in progress). We compare soil temperatures with available observations over Arctic stations and discuss the ability of ERA 40 to reproduce observed interannual variations of soil temperatures.

3-B-3.3

Soil surface CO_2 efflux in a boreal forest: natural environmental controls and responses to atmospheric CO_2 enrichment and air warming

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Soil surface CO_2 emissions represent an important carbon flux in boreal forests. For several years, soil CO_2 efflux was measured in a 50-year-old Scots pine stand under natural conditions in Finland (62°52'N, 30°49'E). Soil surface CO_2 efflux was measured on the top of the moss cover with an infra-red gas analyzer and a closed system with an opaque chamber. For the snow-free period from May to October, measurements were repeated twice a week. In addition, some monthly measurements were made in wintertime. In 1999, for instance, soil surface CO_2 efflux ranged from 0.04 to 0.76 g CO_2 m^{-2} h^{-1}. Soil temperature had a strong effect on the temporal pattern of soil CO_2 emissions. A regression model for the snow-free period of 1999 with soil temperature as the sole independent variable explained 75 % of the variation in soil CO_2 efflux. When water content of the top soil layer and air temperature were included, the coefficient of determination was raised by 10 %. Other variables, such as Julian day, were not significant predictors in this one-year model but could improve the model if several years of measurements were included. In addition to low soil temperatures, depth of snow cover and its structure appeared to control wintertime flux. In spring, snow crust forming caused considerable accumulation of CO_2 in snow. In a whole-tree chamber experiment performed in near-by area, soil surface CO_2 efflux was found to be greater under elevated atmospheric CO_2 than in the control chambers. Warming as well resulted in greater soil CO_2 efflux relative to the control. However, temperature sensitivity of soil CO_2 efflux decreased under experimental warming in the second and third year of the study. On the whole, differences between the treatments and the chamber control decreased year by year.

3-B-3.4

Tree stem diameter change measurements and their connection to transpiration

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Tree stem diameter changes are known to consist of two separable components: an irreversible component due to growth and a reversible component with a diurnal cycle. The diurnal changes correlate strongly with measurements of e.g. temperature, relative humidity, cloudiness, soil water content and shoot water potential [1,2,3,4] and are therefore thought to reflect the water status of a tree. According to the cohesion-tension theory of the ascent of sap, measurements of these diameter changes provide a means of obtaining information about sap flow and water tension inside the stem (e.g. [5]). However, measuring the diameter changes on the bark gives only rough information about water flow in the xylem, because of the different functions of the xylem and the outer tissue in the transfer of matter. This means that the separation of xylem diameter variations from the whole stem diameter variations is essential when studying the connection between transpiration and tree stem diameter changes. We have measured both xylem and whole stem diameter variations at SMEAR II measurement station in Hyytiälä, Southern Finland, and studied their connection to transpiration and mass transfer inside the stem. We have developed a model that calculates xylem diameter variations from measured transpiration and soil water content for a Scots pine tree [6]. In this presentation the model results calculated from transpiration measured by shoot chamber and eddy-covariance techniques are compared and the applicability of stem

diameter variation measurement to estimate transpiration and mass transfer inside the stem are discussed.

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3-B-3.5

Validating Canadian Land Surface Scheme Heat Fluxes under Subarctic Tundra Conditions

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This study tests the ability of the Canadian Land Surface Scheme (CLASS) to generate sensible and latent heat fluxes over two subarctic tundra sites in the Trail Valley Creek river basin, North West Territories (NWT), Canada. CLASS simulations with and without the new organic soil parameterization developed by Letts et al. (2000) were compared with three summer months of measurements at each site. The sites are located in a cryoturbated region and are underlain by continuous permafrost and feature mineral soil hummocks and organic soil inter-hummock zones. Results from Letts et al. (2000) version of CLASS showed significant improvement over the standard version although in both cases, there was an underestimation of latent heat fluxes and overestimation of sensible heat fluxes. The observed soil moisture contents are almost constant at both sites, and they are located in low-lying areas, one in a local depression and the other at the bottom of a valley. Thus, it is reasonable to assume that the constant soil moisture content is maintained by lateral flow from adjacent hillslopes. Since CLASS is a one-dimensional (1-D) column model, a module was added to the Letts et al. (2000) version of CLASS to reflect this 2-D water movement. Simulations were further improved. This additional module is a simple, but effective way to model lateral flow when it is significant.

3-B-4.1

Modelling Mackenzie Basin Surface Water and Energy Cycles during CAGES with the Canadian Regional Climate Model

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[3]*MCN*

The Canadian GEWEX Enhanced Study (CAGES) is a research programme centred on a 14 month long field campaign running from the summer of 1998 through the summer of 1999 over the Mackenzie River Basin. It's purpose is to improve our understanding of water and energy fluxes and reservoirs in the region during this water year through enhanced observing periods of targeted variables, as well as comprehensive modelling studies. In support of this, a developmental version of the Canadian Regional Climate Model, coupled with a third generation physics parameterization package of the Canadian Centre for Climate Modelling and Analysis GCM has simulated the entire period. One of the advantages of this package compared with previous versions is the use of the Canadian Land Surface Scheme (CLASS), and to fully exploit this a detailed high resolution land surface data set has been constructed for North America to be used with the modelling system. In this talk our latest results with the model for the CAGES period will be evaluated against operational as well as CAGES and other specialized GEWEX data sets over the Mackenzie Basin. We will focus particular attention on simulated surface water and energy budgets. Plans for the inclusion of a hydrological component for CLASS will also be discussed.

3-B-4.2

Evaluating data interpolation in moving sparse noisy data to a uniform grid

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As a step towards validating the Canadian Regional Climate Model, a gridded set of observed data needs to be constructed for comparison. The performance of a data interpolation scheme is examined. The ability of ANUSPLIN, a multi-variate, noisy-data interpolator developed at the Australian National University, to reproduce gridded output from noisy data subsets, was examined by first creating data subsets, adding noise to these subsets, then interpolating from them onto the original grid. In the presence of moderate levels of noise (5-10% of field range), and for coarse (10-25% of global set) data subsets, model data recovery is adequate. Furthermore, ANUSPLIN was seen to perform better in regions of weak gradients (away from shore lines), though in areas where data was more isotropic (interior to the domain), the effect of strong gradients was minimal. In an additional experiment, model data was selected to resemble the real observational network (as contained in the Canadian meteorological archive). Interpolation from this set, yielded results that were good on land and near stations. Further interpolation from an augmented set containing extra stations in the North of Quebec (coincident with stations in the Centre d'Études Nordiques), highlight the need for a stronger observational presence in the North.

3-B-4.3

Downscaling ability of Limited-Area Models

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Nested limited-area models (LAMs) have been used by the scientific community for a long time, with the implicit assumption that they are able to generate meaningful small-scale features that were absent in the initial and in the lateral boundary conditions. This hypothesis has never been seriously challenged in spite of some reservations expressed by the scientific community. In order to study this hypothesis, a perfect-model approach is followed. A high-resolution large-domain LAM driven by global analyses is used to generate a "reference run". These fields are afterwards filtered to remove small scales in order to mimic a low-resolution run. The same high-resolution LAM, but in a small-domain grid, is nested with these filtered fields and run for several days. Comparison of both runs over the same region allows us to estimate the ability of the LAM to regenerate the removed small scales. Results show that the small-domain LAM recreates the right climatology but is incapable of reproducing the same deterministic evolution with the precision required by a root-mean-square (RMS) measure of error. However, when a probabilistic approach is used to analyze the same dataset, results are more encouraging. This suggests that, despite the inability to perform as point-wise forecasts, useful information can be generated by LAM simulations.

3-B-4.4

Sensitivity of the Canadian RCM to the surface and atmospheric initial conditions

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Traditionally it is usually assumed that a simulation performed with a Regional Climate Model using a given configuration and lateral boundary conditions (LBC) is unique. In other words a RCM simulation is strongly controlled by the LBC and should be independent of the initial conditions (IC). In this study we look further at this assumption. The basic experimental set-up is built as follow. Three one-year Canadian RCM (CRCM) simulations covering the north east of America starting on 1 January, are generated using identical LBC supplied from a GCMii current climate simulation and climatological SST. The only difference between each simulation lies in the IC used for the atmospheric and/or the surface simulated fields. By comparing the results of the different simulation, it is possible to look at the sensitivity to surface and/or atmospheric IC fields. The results show that during the first few months every CRCM simulations follow each other closely until the beginning of summertime when there is an increase of the discrepancies between all pairs of simulations. However, simulations sharing the same surface IC take longer before developing differences. After summertime the level of similarity between the simulations reaches values comparable to the first few months. Analysis of the results suggests that variation of the residency time is partially explaining the variation of the differences. However, the level of control exerted by the LBC is also influenced by the level of activity of the more stochastic activity of parameterised sub-grid scale processes.

3-B-4.5

Real-Time High-Resolution Modelling of Precipitation in the St. Lawrence Valley and New England States

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Accurate quantitative precipitation forecasting (QPF) is often considered to be the "holy grail" of meteological prediction. A reliable precipitation forecast requires not only an accurate representation of the large-scale atmospheric dynamics and thermodynamics, but also the reliable modelling of small-scale orographic and stochastic processes. Advances in affordable scientific computing platforms are beginning to make regional high-resolution numerical forecasting accessible to both operational centers and research units. The recent acquisition of high-speed machines both at the National Weather Service (NWS) forecast office in Burlington, Vermont, and at McGill University in Montreal, has made possible this cooperative investigation of local precipitation patterns. The fine-scale structure of the orographic features in the St. Lawrence Valley and New England states adds to the challenge of QPF. Local terrain-induced flows are clearly sub-gridscale for the models run by both the American and Canadian operational centres. Cannel flows and sharp diurnal cycles may enhance predictability at a given location, but are virtually impossible to simulate without a very high-resolution model integration. Likewise, the strong, near-surface frontal boundaries often observed in the region can be resolved only with grid spacings on the order of 3 km or less. A workstation version of the Eta model, and an updated version of the Mesoscale Compressible Community model are being run at NWS Burlington and McGill University, respectively. Implementation and development issues will be outlined, and preliminary results from both systems will be compared. The long-term objectives of the project, namely to enhance our understanding and ability to predict precipitation at high resolution, will be presented and discussed.

3-B-5.1

Overview

Susan Woodbury
Chair, CMOS Private Sector Committee and Meteorology Division Manager
Seimac Limited, Darmouth, Nova Scotia, Canada

The CMOS Private Sector Task Force has developed an Industry Strategy for Meteorology in Canada. An overview of the strategy will be presented. Several members of the task force will be present and ample time will be allocated for a question and answer period.

3-B-5.2

MSC in transition

Catherine Conrad
Director, Meteorological Services and Business Policy

In the past the meteorological sector in Canada and around the world was composed exclusively of government agencies. Today, the situation has changed and while the scientific infrastructure is still largely based on public sector resources, there is a growing meteorological industry that contributes to the prosperity of the economy. It is essential to have the right mix of public and private provision of weather services for efficiency and continued growth of this sector.

The MSC has been encouraging the growth of this activity through its work with the private, public and academic sectors on the industry strategy. In addition, MSC has been working internally and in consultation with stakeholders to position itself to allow for the development of this sector while meeting the needs of all stakeholders. This includes reorienting its role and activities in the market place, developing a new data access framework, and looking at opportunities to work with public and private stakeholders.

3-B-5.3

Challenges of commercialization of university research

Charles Lin

3-B-5.4

Education and training of atmospheric scientist: The role of the universities

Peter A. Taylor
Department of Earth & Atmospheric Science, York University, Toronto, Ontario, Canada

Several Canadian Universities have undergraduate honours degree programmes and Certificates or Diplomas in Atmospheric Science or Meteorology. These will be reviewed. Other universities include some atmospheric, air quality or climatological work in their programmes and both groups have graduate and research activities in the Atmospheric Sciences.

The undergraduate programmes have for many years been structured to meet AES/MSC needs and care has been taken to ensure that graduates satisfy the MSC "Education Requirements". These requirements focus on good coverage of the theory of atmospheric physics and dynamics plus some synoptic analysis and forecasting. Much of the practical training for forecasters in done by MSC, or by the Weather Network, once they have hired our graduates as trainee forecasters. US universities tend to put more emphasis on practical forecasting.

With improved prospects of employment for meteorology graduates in the private sector, should the Universities adjust their programmes? If so how? There are also internal University pressures to review undergraduate programmes in these areas, which have typically included many upper level courses with relatively low (10 or less) students. These are not financially viable and are constantly under pressure. If undergraduate enrolment in Atmospheric Science does not increase some programmes may be in danger.

3-B-5.5

Private Sector Meteorology in the United States

Jimmie Smith
Chair, AMS Board on Private Sector Meteorology

As indicated by the increase in the number of people employed in the industry, the private sector weather industry in the United States has grown substantially during the past 20 years. In 1982, a report prepared by the National Advisory Committee on Oceans and Atmospheres stated, «The number of meteorologists in the private sector is estimated to be about 800.» Today, in 2002, the American Meteorological Society estimates more than 3,500 of its members are involved in the private sector. An examination of the current status of the private sector weather industry further illustrates this growth by considering the various types of companies, their approximate sizes, and the markets they serve. The present roles of the private sector, the public sector, and the academic community in providing meteorological services in the United States are also reviewed.

3-C-1.1

Did the Northern Hemisphere Sea-Ice Reduction Trend Trigger the Quasi-Decadal Arctic Sea-Ice Oscillations?

Jia Wang[1] and Ikeda Moto[2]
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[2]*Graduate School of Environmental Earth Science, Hokkaido University, Sapporo, Japan*

The nature of the reduction trend and quasi-decadal oscillations in northern hemisphere sea-ice extent is investigated. The trend and oscillations, which seem to be two separate phenomena, were found in data. This study proposes a hypothesis/theory that the Arctic sea ice reduction trend in the last three decades triggered the quasi-decadal Arctic sea ice oscillation (ASIO), based on both a conceptual model and data analysis. The theory predicts that the quasi-decadal oscillations are triggered by thinning in sea-ice, leading to the ASIO being driven by a strong positive feedback between the atmosphere and ocean. Such oscillations between the Arctic Basin and GIN seas are predicted to be out of phase with the phase difference being 3Pi/4. The wavelet analysis of the data reveals that the quasi-decadal ASIO did occur actively since 1970s following the trend (i.e., as sea ice became thinner and thinner), although the atmosphere experienced quasi-decadal oscillations in much of the last century. The analysis also confirms the out-of-phase prediction between these two regions, which varied from 0.62Pi in 1960 to 0.25Pi in 1995.

3-C-1.2

Identification of an Intra-Month Regime Shift over the North Atlantic

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The North Atlantic Oscillation (NAO) is generally accepted as being an inter-annual oscillation in the atmospheric mass field. The positive phase of the NAO is associated with a strong Icelandic Low and is the result of storms that track in a northeasterly direction towards Greenland. The negative phase has a substantially weaker Icelandic Low or a blocking high over Greenland and is the result of storms that track in an easterly direction across the North Atlantic. Our research shows that not only do the flow regimes associated with the NAO appear on shorter timescales, but that the shifts in the regimes occur on intra-month timescales. Making use of the 6-hourly NCEP Reanalysis, we identify these regime shifts or interventions for a location in the Labrador Sea and for a location in the GIN Sea (just east of Greenland). By triggering on these interventions in the pressure field, we create composites that show the temporal structure of the regime shift in the pressure, heat flux, and precipitation fields. Plots of the spatial structure of the regimes illustrating the respective flow regimes are also shown.

3-C-1.3

Shifts in the distributions of climate variables in the Alpine region in response to the behavior of the North Atlantic Oscillation

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An investigation has been undertaken in order to assess the manner in which the North Atlantic Oscillation (NAO) influences not only general, average, climatic conditions, but also the extremes of dynamic and thermodynamic variables. By choosing representative sites in the Swiss Alps, the present study shows that there is a high sensitivity of the extremes of the probability density functions of temperature, moisture and pressure to

periods when the NAO index is either highly-positive or strongly negative. When the NAO index is strongly positive, temperatures and pressure shift towards positive anomalies, and there is a general reduction in atmospheric moisture at high elevations. As a result of the highly-positive nature of the NAO index in the latter part of the 20th Century, it is speculated here that a significant part of the observed warming in the Alps results from the shifts in temperature extremes induced by the behavior of the NAO. These changes are capable of having profound impacts on snow, hydrology, and mountain vegetation.

3-C-1.4

La Climatologie dans les Iles de l'Arctique Canadien - Vingt ans plus tard.

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Il y a un peu plus de vingt ans qu'une sérieuse analyse du climat des îles de l'arctique canadien a eu lieu (Maxwell, 1980). Depuis ce temps, il y a eu un nombre d'études et de projet de recherches dans les îles, mais tous ont un aspect de recherche spécifique à un site ou à un paramètre du climat. Cette communication veut reprendre l'idée de Maxwell mais en y appliquant une approche pluridisciplinaire. La présentation consiste d'abord à revoir l'évolution de la recherche climatologique dans les îles depuis cette publication de Maxwell. Coïncidant à cette synthèse de Maxwell, était l'émergence du phénomène de l'intérêt dans le changement de climat qui depuis, est passé au premier rang d'activité de beaucoup de chercheurs en climatologie. Ainsi, ce survol démontre une concentration de recherches climatique pour l'arctique, dans le domaine de climatologie synoptique. Il est aussi évident qu'une majorité des publications proviennent hors du pays, reflétant la variation de support pour les recherches climatiques dans ces îles. Cette communication comprend aussi une synthèse des conclusions importantes des recherches climatologiques des derniers vingt ans issues de ces analyses de climatologie synoptiques, ainsi que les autres disciplines en climatologie et autres (océanographie, glaciologie, hydrologie) qui contribuent à notre connaissance de la climatologie des îles. Une dernière partie de cette analyse comprend une revue des problèmes associés non seulement avec les données qui existent pour cette région mais aussi les problèmes de mesures qui continuent à influencer ces données.

Maxwell, J.B. 1980. Le climat des îles arctiques et des eaux adjacentes du Canada. Vol. 1 & 2, Études climatologiques numéro 30. Environnement Canada, Service de l'environnement atmosphérique, Downsview. ISBN 0-660-50641-6

3-C-1.5

On the interannual variability of severe convection in Alberta based on lightning, hail, tornado, radiosonde, and rainfall observations

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Several data sets are used to compile a "climatology" of severe convection for Alberta. Observational data included are cloud-to ground lightning strikes, hailfall reports, rain gauge measurements, radiosonde data, tornado reports, and radar observations. The emphasis is on identifying interannual variability in severe summertime convection.

3-C-2.1

Conséquences de la fonte rapide des coins de glace sur la géomorphologie et l'hydrologie des terres humides arctiques, Ile Bylot, Nunavut.

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Dans les régions à pergélisol continu, les champs de polygones à coins de glace occupent de vastes superficies. Cependant, la déstabilisation soudaine du régime thermique du pergélisol peut entraîner de profondes modifications géomorphologiques du milieu. Dans la vallée du glacier C-79 sur l'île Bylot, un réseau de gros coins de glace s'est développé dans des sédiments éoliens, de versants et organiques au cours des derniers 4000 ans. Au cours des étés 1999-2001, l'infiltration de l'eau de fonte des neiges dans le mollisol des bourrelets de polygones a entraîné la fonte des coins de glace et la formation subséquente d'un réseau d'écoulement souterrain à l'intérieur du pergélisol. L'eau de fonte des neiges a été canalisée dans les dépressions engendrées par la fonte des coins de glace et s'est ensuite écoulée sous la surface. Le réseau souterrain a progressé rapidement, suite à l'érosion thermique par l'eau courante, essentiellement le long des coins de glace. Des tunnels de plus d'un mètre de hauteur, de plusieurs mètres de largeur, et de plusieurs dizaines de mètres de longueur minent ainsi le pergélisol. Éventuellement, les arches de ces tunnels s'effondrent sous le poids des sédiments sus-jacents. Comme les sols sont riches en glace interstitielle, leur exposition au rayonnement solaire durant le reste de l'été entraîne la fonte de la glace et la destruction subséquente des polygones. La superficie affectée par la fonte des coins de glace est considérable et peut atteindre plus d'un km^2 par année. Ce phénomène de thermokarst entraîne de profondes modifications de l'écosystème local. Effectivement, la destruction des coins de glace mène à la formation d'un nouveau réseau hydrographique qui progresse annuellement le long du réseau polygonal et l'abaissement de la pente du terrain suite à la fonte de la glace de sol entraîne le drainage massif des terres humides polygonales. Lorsque le réseau thermokarstique atteint la berge des lacs de thermokarst, ces derniers sont alors drainés de façon catastrophique et soudaine.

3-C-2.2

Sensitivity of the hydrology of a northern climate watershed to variations in incoming solar radiation fluxes

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[2]*Department of Civil Engineering - Hydrology, University of Waterloo, Waterloo, Ontario, Canada*

MAGS is the part of GEWEX (The International Global Energy and Water Cycle Experiment) that is focused on the Mackenzie River Basin. One of the stated objectives of MAGS is to model the critical components of the water and energy cycles that affect the climate of the Mackenzie Basin. An important outcome will be validated numerical simulations with coupled atmospheric-hydrological-land surface scheme models that, on monthly or longer time scales, will reproduce the observed transport of moisture and energy into and through the Mackenzie River Basin. The distributed hydrological model WATFLOOD and the land surface scheme CLASS have already been coupled into WATCLASS. Atmospheric input to WATCLASS is provided by the output from an atmospheric model. Uncertainties in WATCLASS model simulations can arise from limitations of WATCLASS itself, as well as from the data that are used to drive the model. All aspects of the simulations need to be studied in order to assess the reliability of the model results. Thus, one needs to evaluate the output of the atmospheric model and to assess how errors in the atmospheric model output may impact on the basin hydrology, as modeled by WATCLASS. One of the key fields that couples the atmospheric model and WATCLASS is the incoming solar radiation flux. The question that we are addressing is how sensitive is the modeled hydrology of this northern climate watershed, to uncertainties into the solar radiative input. To assess this sensitivity, two WATCLASS model runs are compared. In the first run, the atmospheric data that drive WATCLASS (pressure, humidity, temperature, precipitation, wind speed, longwave and shortwave radiation) are obtained from the output of the GEM model for the year October 1998 to September 1999. The second run uses the same input as the first run except that the shortwave radiation fluxes are replaced by fluxes retrieved from satellite measurements. Results from these comparisons will be presented, with emphasis on the snowmelt amount in spring, the freeze-up in fall and the evapotranspiration when the surface is free of snow.

3-C-2.3

Link between climate and river runoff in north-eastern Quebec

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The hydro-electric resources of north-eastern Québec and Labrador are greatly dependent upon the precipitation and temperature patterns of the area. In order to ascertain the variability of this resource, links between these climatic parameters and planetary driving forces is of utmost interest to energy sectors of the province. Large-scale systems such as the arctic high (ARH), the icelandic low (IL) and the polar vortex cycles which are represented by the arctic oscillation (AO), are considered as the main factors influencing the variability of northern hemisphere climate. For years, scientists have known that the NAO (north atlantic oscillation) index explained significantly well european winter temperature distributions. Shabbar introduced in 1996 the BWA (Baffin island-west atlantic) index which better reflects the temperature variability of north-eastern North America. In order to evaluate the state of hydrological conditions in north-eastern Quebec and Labrador and to link annual river runoff variability with respect to large-scale systems such as the IL and the NAO, an analysis of Quebec's northern latitude runoff conditions was performed for the period of 1950-2000. According to Shabbar, our results reveal also that river runoff variability before 1970 is dominated by interannual fluctuations, whereas interdecadal fluctuations seem to underlie the pattern thereafter. Furthermore, evidence suggests that precipitation conditions during Winter, and thus river runoff during spring, can be linked to the intensity, structure and spatial localisation of these large-scale systems. The relationships between changes in these systems during the last 30 years and climate variability and impacts for river runoff will be presented.

Shabbar, A., Higuchi K., Skinner W., and Knox J.L. 1997. 'The Association between the BWA index and the winter surface temperature variability over eastern Canada and west Greenland', Int. Journal of Climatology, **17**, 1195-1210.

3-C-2.4

Inter-Annual Rainfall Variability over the Sudan -Sahel.-A new Perspective.

Zakariyau Abdulrasheed

Abnormal rainfall fluctuations especially in the Sudan Sahara African and Sudan Sahel region of Nigeria (to be specific since the 1970's) has had a lot of influence on human activities of which agriculture is the main stay of the peoples' economy. This has necessitated serious drought mitigation measures depending on their distribution and characteristics. It is on this basis that some operational indices of rainfall variabilities have been discussed in an attempt to stress their strength and limitations. daily rainfall data for 31 years (1969-1999) for 12 stations in the Nigerian Sahel were collected and analysed to show inter annual variability. A new index proposed as monsoon quality index MQI(Usman, 2000) was applied to the data. Results show clearly the extreme shortfalls in rainfall in the Sahel in 1973 and 1983 and the good years in mid and late 70's and 80's, MQI is able to depict location- specific features as well as spatial variability.

3-C-3.1

Ekman Volume and Heat Fluxes in the North Atlantic

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Results will be presented from a study examining Ekman Volume and Heat Fluxes in the North Atlantic. The fluxes were calculated using scatterometer wind stress data and Along Track Scanning Radiometer sea surface temperature data. Temporal and spatial variability for the period 1992 -1998 will be discussed. Correlations between the fluxes and the North Atlantic Oscillation and other indices will be examined.

3-C-3.2

Can the dynamics of the ACC explain why is Antarctica cooling?

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Recent analysis of observations has suggested that while the globe as a whole, and especially the Arctic is warming, Antarctica is actually cooling. It is of vital importance in our examination of climate change to understand the different behaviour of the two poles. While both poles are surrounded by atmosphere jet streams, the oceanography of the two regions is diametrically opposite. While the Arctic is an ocean surrounded by land, the Antarctic is a land mass surrounded by ocean. Importantly, this allows the southern jet stream to be coupled to an oceanic equivalent, the Antarctic Circumpolar Current. Recently we have completed an in depth analysis of the dynamics of the ACC, specifically concentrating on how it reacts to atmospheric forcing. It has illustrated that the ACC is established as a balance between surface forcing, wind stress and air-sea buoyancy fluxes, and interior eddy fluxes. In this talk, we examine how such a balance would change with the current climate changes. Our goal will be to illustrate that it is the different ocean dynamics surrounding the poles that account for their different responses to global warming.

3-C-3.3

The boundary layer structure over cold oceanic surface simulated by the Canadian Regional Climate Model: example of Hudson Bay in summertime

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The Hudson Bay (HB) climate system is dominated by the presence of a seasonal sea ice cover over 8 months per year. In summer, the duration of the short ice-free period (typically from the end of July early November) is crucial for the mixed-layer heat storage of the HB. During the ice-free summertime period, the sea surface temperature (SST) over the most part of HB remains cooler (typically from 1°C in the north to 10°C in the south) than the surrounding land surface temperature. The low-level air temperature is cooled by heat intake over the Bay. This produces a regular shallow low-level inversion that increases the near surface atmospheric stability over sea water. This has effects on humidity, temperature and wind profiles, as well as low-level clouds and radiation. In order to correctly simulate the near-surface wind and temperature used to drive the ice-ocean model of the HB in summer, it's crucial to accurately reproduce the boundary layer characteristics and the surface fluxes, especially in stable conditions. The first results obtained over the HB in August 1996 with the CRCM (Canadian Regional Climate Model at 25 km of horizontal resolution with 40 layers in the vertical) using the physical

package of GCMII (Canadian Global General Circulation Model version II, described in McFarlane et al., 1992) suggest that the screen-level fields and the surface fluxes are not correctly reproduced when we compare the CRCM fields with available observations and with the reanalyses of the Canadian Forecast Model (on the regional grid, i.e. at 35 km). The intensity of surface sensible heat fluxes and near-surface wind speed are underestimated in the CRCM. Also, the CRCM 2-m temperature is too cold with a strong dependence to the SST. This is the result of the suppression of the low-level turbulence in the boundary layer, i.e. due to an over-stabilisation effect in the model. A new calculation of the surface-layer exchange coefficients using the parameterization developed by Abdella and McFarlane (1996) resolves a part of these biases with an increase in the low-level turbulence in stable conditions. We analyse the improvements issued from the new parameterization on the accuracy of the CRCM boundary layer structure with systematic comparisons with ship, buoy and meteorological datasets over and near the HB during the August month.

McFarlane, N.A., G.J. Boer, J.P. Blanchet, and M. Lazare. 1992: The Canadian climate centre second-generation general circulation model and its equilibrium climate. J. Climate, 5, 1013-1044. Abdella, K. and N.A. McFarlane. 1996: Parameterization of the surface-layer exchange coefficients for atmospheric models. Boundary-Layer Meteorol., 80, 223-248.

3-C-3.4

Two-way coupling between the GEM atmospheric model and an ice-ocean model of the Gulf of St. Lawrence

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Experiments are presented where the Canadian operational GEM atmospheric model is coupled to the ice-ocean Gulf of St. Lawrence model developed at l'Institut Maurice-Lamontagne. A storm event from March 1997 is simulated where the two-way interaction between the atmosphere and the ocean surface is shown to be important in forecasting accurate air temperature near coastal areas. Compared with its original non-coupled setup, the GEM model with a dynamic ice cover produces more accurate air temperature forecasts for 71% of 46 observation stations. The increased modeled air temperature had an important effect on the ice-ocean model.

3-C-3.5

High Latitude Air-Sea Interaction as Expressed in Data from OWS Bravo

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Deep water formation at high latitudes is believed to be the driving mechanism behind the ocean's thermohaline circulation. The exchange of heat and water with the atmosphere causes the density of the surface waters to change, with subsequent downwelling and upwelling resulting as the system relaxes towards convective equilibrium. We study the characteristics of this atmosphere-ocean exchange by studying the temporal variability of the buoyancy flux at Ocean Weather Station Bravo, a location where deep water formation is known to occur. We find that there is significant high frequency variability in the buoyancy flux attributable to the passage of synoptic weather systems, variability that is masked by monthly analyses. At high latitudes, precipitation plays a significant role in the buoyancy flux. If it is ignored, the buoyancy loss is overestimated. Precipitation also causes the buoyancy flux to become positive during the passage of a cyclone. The timescale for the changes in buoyancy flux is found to be similar to the timescale for the convective plumes in the ocean, suggesting a link between the two. A strong negative correlation is also found to exist between the sensible heat flux

at Bravo and the North Atlantic Oscillation. The quality of the NCEP reanalysis fields is also examined by comparing the reanalysis data in the vicinity of Bravo to the Bravo dataset.

3-C-4.1

The propagation of tides, waves and sediment transport at the mouth of House-Harbor and Great-Entry lagoons, Magdalen islands, Gulf of St. Lawrence.

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House Harbor (HH) and Great Entry (GE) lagoons in Magdalen Islands are part of a two-lagoon system flushed by Gulf of St. Lawrence waters through separate and distant (40 km) tidal inlets. Magdalen islands being located close an M2 semi-diurnal tidal amphidromic point, one can expect different tidal phases and amplitudes in the vicinity of both inlets and within the lagoons. This study examines the tidal circulation in both lagoons and the resulting non-cohesive sediment transport near their tidal inlets using 2D numerical models and field observations. Analysis of water level and current time series measured at 12 stations within the lagoons and in adjacent coastal waters reveals that the HH lagoon inlet is of a “restricted” nature and retards the tidal propagation by more than two hours. Tidal currents through both inlets exceed 1.0 m/s. Numerical simulation results are presented for the tidal propagation in both lagoon and for the non-cohesive sediment transport under the influence of wind, tidal and wave-induced currents near both inlets.

3-C-4.2

La dynamique hivernale de l'estuaire Portneuf

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[4]*New York State University, Delmar, New York, USA*

Constatant la pénurie de connaissances des phénomènes hivernaux estuariens, le Comité canadien sur les processus fluviaux-glaciaux et l'environnement (de l'Union géologique canadienne) a demandé à l'Université Laval et Hydro-Québec de réaliser des études pour cerner la dynamique des glaces dans les rivières à marées et ses effets sur l'environnement. L'estuaire choisi fut la Portneuf. L'estuaire est situé sur la côte nord du fleuve Saint-Laurent près de Forestville. Son chenal principal est environ 5.5km de long et 200 m de large. Le marnage varie de 1.9m à 3.8m. Il y a un débit moyen annuel de 64 m^3/s. En 2000, l'étude avait des volets ethnographiques et techniques. Le savoir écologique des populations locales sur les glaces d'un estuaire a été accolé au langage technique. L'étude sur le terrain a été menée au début de mars. Ce sont donc les conditions de fonte de la couverture de glace qui ont été décrites. En 2001, une deuxième étude de terrain fut au sommet de l'hiver. Les observations ont enrichi la connaissance des caractéristiques des glaces et ont permis de mettre en lumière la variabilité inter-annuelle. Ainsi, il fut constaté que le temps de contact entre l'eau salée et la glace est déterminant pour expliquer l'épaisseur et la nature de la glace. En 2002, en utilisant des sondes de températures, salinité et courant, une troisième campagne de terrain fut lancée. Elle a permit de cerner les échanges entre l'eau douce et l'eau salée en présence de glace. Dans la présentation, les relations entre les épaisseurs de glace, la formation cristalline de la glace, l'intrusion saline et la modification des niveaux, courants et débits sont illustrées.

3-C-4.3

Évolution dynamique de l'embouchure de la Sainte-Marguerite de 1931 à 2001

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L'analyse de 16 photographies aériennes, prises de 1931 à 2001, a permis de faire ressortir les principaux éléments marquant l'évolution dynamique de l'embouchure de l'estuaire de la rivière Sainte-Marguerite. L'extrémité ouest de la flèche principale de l'embouchure a connu des progressions et des érosions marquées durant cette période. Au cours des années 1950, la façade maritime de la municipalité de Gallix a subi une érosion importante. L'embouchure de la Petite rivière Sainte-Marguerite s'est significativement déplacée dans les années 1970, alors que le talus longeant sa rive gauche s'est érodé progressivement. L'épisode le plus récent d'érosion de la flèche principale s'est produit entre 1996 et 2000. L'extrémité ouest de la flèche a été tronquée d'environ 450 m, ce qui a contribué au développement d'un imposant delta de flot. En 2001, on note un retour à un engraissement timide de la flèche et à une chasse graduelle du delta de flot. L'événement hydrologique le plus important qu'a connu la rivière depuis les dernières 70 années, est la mise en eau du réservoir Sainte-Marguerite 3 qui a débuté le 1er avril 1998. Depuis, les apports d'eau douce à l'estuaire ont diminué de 76 %, passant de 137 m^3/s à 31 m3/s en moyenne annuelle. Sans ces apports, le niveau d'eau moyen à l'étale des basses mers dans l'estuaire s'est abaissé de 0,22 m à l'embouchure et jusqu'à 0,43 m près de la tête. Une érosion générale du chenal et d'une bonne partie des hauts-fonds de l'estuaire s'est aussi produite. On estime qu'environ 500 000 m^3 de matériaux se sont alors déplacés. Les chenaux ont toutefois gardé la même aire d'écoulement et une profondeur équivalente à celle observée avant 1998. En effet, la nature sableuse du lit de l'estuaire impose un équilibre hydraulique entre le débit dominant (marée et rivière) et la section d'écoulement. La plupart des modifications de la flèche notées sur les photographies aériennes sont essentiellement liées à des événements météorologiques, et plus particulièrement aux vagues de tempêtes en provenance de l'est. Aucun lien direct n'a pu être dégagé entre l'évolution de la flèche et le régime hydrologique de la rivière Sainte-Marguerite et ce, même en période de crues printanières.

3-C-4.4

Hydrodynamique de l'estuaire Richibouctou, Nouveau Brunswick: Étude et modélisation.

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L'estuaire Richibucto (Nouveau Brunswick) est situé dans le détroit de Northumberland. Estuaire peu profond, à barre sableuse, il est similaire à plusieurs autres de la région atlantique. Le travail présenté ici consiste dans l'étude de séries de données physiques collectées in situ en 1999 et 2001 et dans l'utilisation d'un modèle numérique en trois dimensions pour simuler la circulation des eaux. Les mesures de courants et de niveaux d'eau font apparaître l'influence du point amphidromique, situé au Nord du détroit, sur

le type de marée dans l'estuaire. Par ailleurs, des profils de température et salinité effectués sur plus de trente kilomètres depuis l'embouchure ont révélé le caractère bien mélangé de l'estuaire, en période de faible débit d'eau douce. Tenant compte de ces conditions particulières, un modèle numérique en trois dimensions (MIKE3) a été développé et utilisé pour simuler la circulation des eaux dans l'estuaire. Enfin ce modèle a permis d'estimer les flux à travers les sections délimitant une région particulière ainsi que le temps de résidence des eaux dans ce secteur, où un projet de développement de sites ostréicoles est en cours.

3-C-4.5

Three-Dimensional Numerical Study of Barotropic Tidal Circulation in Lunenburg Bay, Nova Scotia

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We developed a high-resolution, eddy-resolving coastal ocean circulation model for Lunenburg Bay, Nova Scotia using the free-surface version of CANDIE, as part of an interdisciplinary research project known as MEPS (Marine Environmental Prediction System). The main objective of MEPS is to develop a real-time, data-assimilative prediction capability for the coastal regions of Atlantic Canada. As the first step, we forced this high-resolution coastal ocean model by barotropic tides. The model results reproduce reasonably well the tidal circulation in the region, with strong tidal currents through the narrow channels connecting Lunenburg Bay and Upper and Lower South Coves. The model results also reproduce well the large differences in magnitudes and phases of the barotropic tides in Upper South Cove and Lunenburg Bay. The time-mean model results reveal several barotropic gyres over the western Lunenburg Bay, Upper and Lower South Coves, and the narrow channels, indicating the importance of the nonlinear tidal dynamics over these areas.

3-D-1.1

Weather, Climate and History

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We report on an undergraduate course on Weather, Climate and History that has been offered at McGill University for the past 2 years, jointly between the Department of Atmospheric and Oceanic Sciences, and the Department of History. This is the first time that the Faculties of Science and Art at McGill have worked together to offer an undergraduate course. The course is offered as a First Year Seminar, with enrolment limited to first year undergraduate students and capped at 25 students. The course examines the nature of climate variability and its impact on human history, and also touches on potential climate change in the near future. An assessment of the consequences of climate change depends upon a proper understanding of the past influence of weather and climate. Specific topics discussed include reconstruction of past climate, peopling of continents, impact of climate on agriculture, social revolutions and disease, and influence of weather on major battles and price fluctuations. The course consists of lectures by the core instructors, guest lectures by scientists, historians, and economists, student debate and presentations. The evaluation of student performance is through participation, presentation and a term paper. Evaluation by students of the course has been very favourable.

3-D-1.2

Regional Climate Change Scenarios in Atlantic Canada Utilizing Statistical Downscaling Techniques: Preliminary Results

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Atlantic Canada is situated in a very diverse environmental area along the east coast of Canada, spanning almost 20 degrees of latitude and 20 degrees of longitude. The climate of the region is varied, encompassing both coastal and continental regimes and influenced by several major ocean currents and mountain ranges. In order to best describe the expected climate change impacts for the region, climate change scenarios and climate variables must be developed on a regional, or even site-specific, scale. Statistical techniques to "downscale" climate variables from global climate models are utilized to generate the downscaled climate variables in that region. Homogonized daily mean, maximum and minimum temperature data for 14 sites across Atlantic Canada over the last 30 years was taken from the Historical Canadian Climate Database and used as the basis for developing the initial statistical relationships. Essentially, a predictor-predictand relationship is defined between global climate model values and the observed values at specific sites. Future climate variables (predictors) are then extracted from various model experiments. Those predictors are used to provide downscaled climate variables (predictand) that are applicable to those specific observed data sites. The resulting values are intended for use by climate change impacts researchers who want to apply climate variables on a regional scale in future climate impact studies. These researchers' interests span many sectors including agriculture, forestry, biodiversity and natural resources. Future work intends to expand the climate variable database as well as deliver them on a small-scale grid as well as at specific sites.

3-D-1.3

North Atlantic Ocean Wave Climate Change Scenarios

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Aiming to produce an engineering-quality, homogeneous, long-term wind and wave data base for assessment of the climate, trends and variability of ocean waves in the North Atlantic, the Climate Research Branch of MSC has finished an intensive reanalysis of surface winds and used the reanalyzed winds to produce a 40-year (1958-1997) numerical hindcast of ocean waves in the North Atlantic. This wave hindcast was found to have excellent agreement with both in situ and satellite altimeter waves. It was also found to have significant changes in significant wave height (SWH) extremes, which are found to be closely associated with changes of sea level pressure (SLP). In this study we construct wave climate change scenarios for the North Atlantic ocean, using the possible future climates projected by the CGCM2 simulations. We first used a statistical approach --- redundancy analysis to relate observed SLP to ocean wave statistics (means and extremes of SWH) derived from the 40-year hindcast. This observed SLP-SWH relationship was then used to project possible future changes in the wave statistics given the CGCM2 simulated changes of SLP under different forcing scenarios. Prior to the scenario construction, the simulated SLP was first evaluated against the NCEP reanalysis, to remove systematic biases to the extent possible. For the 1958-1997 period, the observed trend patterns of SWH were well re-produced in the projections, but the observed amplitude of trend was substantially underestimated. For the next century, the northeast North Atlantic is projected to have significant increases of SWH in winter, and the central North Atlantic, to have significant increases in fall. The rate of increase is less than 2 cm/year, which is very likely underestimated. Not surprisingly, a slower increase in greenhouse gas forcing was found to be associated with a lower rate of change in SWH.

3-D-1.4

Changing Sea Level - Changing Tides in the Bay of Fundy

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This work addresses questions relating to flood risk from increasing high water levels in the Bay of Fundy, induced by climate change. High water levels can vary in time from both changing mean sea level and from changing tides. We show here that the two are related. An Analysis of long term sea level records has been done by Smith and Blanchard (Dalhousie) as part of this study and will be briefly reported here. That study showed that independent of climate change, sea level and tide range are increasing in the Bay of Fundy/Gulf of Maine system. The modelling work shows that local tectonic changes in sea level are presently giving rise to increasing tides. The combined effects of present day sea level rise, climate induced sea level rise, and the increasing tidal range they induce, will give rise to a flood risk significantly higher than that from considering the climate induced sea level in isolation. If the model predictions are accurate, the risk of flooding at higher high water will increase dramatically over the coming century.

3-D-1.5

Applying Results from the CCAF Storm Surge/Coastal Erosion Project along the B.C. Coast

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Studies conducted jointly by the Canadian Hydrographic Service at the Institute of Ocean Sciences and Applications and Services of the Meteorological Service of Canada (Pacific and Yukon Region), and supported by funding from the Canadian Climate Action Fund (CCAF), have identified relationships between sea water levels at locations along the BC coast and meteorological conditions. Statistical methods were utilized to study these relationships. Areas susceptible to damage and flooding from high water and waves were identified, and a set of equations was developed based on a multiple linear regression analysis of storms and water levels observed along the south coast of British Columbia over a seven year period. It is now understood that coastal flooding is a problem not only for the future, but for today as well, as was proven by flooding in the Greater Vancouver Regional District at Boundary Bay in March, 1999. In that event, high tides coincided with low atmospheric pressures as a deep storm moved just to the west of the area. Strong winds accompanying the storm resulted in high water and large waves that breached a seawall resulting in the flooding of a Vancouver subdivision. This presentation reviews results from the project and makes recommendations for the implementation of an operational war ning production system for coastal British Columbia.

3-D-1.6

Trends in climate change indices over Canada

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Trends and variability in Canadian temperature and precipitation have been recently analyzed over the period 1900-1998 [1]. The annual mean temperature has increased by 0.9°C in southern Canada (south of 60°N), and the largest warming was observed during winter and spring. Significant decreasing trends were found in the frequency of extreme cold temperatures, however, no trends in the number of extreme warm days were observed. Precipitation analyses have shown that the annual totals have increased by an average of 12% in southern Canada. This increase was mainly due to an increase in small to moderate events, and no consistent trends were observed in extreme precipitation over the past 99 years. This study continues the analysis of climate trends and variability in Canada, but from a different perspective. Indices of climate change have been selected to evaluate the potential impacts of climate change on our society and environment [2]. For examples, trends are computed in the number of frost days, length of growing season, days with snow, greatest multi-days precipitation. These indices are based on homogenized daily temperature and precipitation which are datasets adjusted for site relocation and changes in observing programs [3,4]. This analysis examines the temporal and spatial characteristics of selected Canadian climate change indices over 1900-2000. [1] X. Zhang, L.A. Vincent, W.D. Hogg and A. Niitsoo, “Temperature and precipitation trends in Canada during the 20th Century”, Atmos.-Ocean, 38, 395-429 (2000). [2] L.A. Vincent and É. Mekis, “Indicators of climate change in Canada”, Proceedings of the First International Conference on Global Warming and the Next Ice Age”, Dalhousie University, Halifax, Canada, 111-114 (2001). [3] L.A. Vincent, X. Zhang, B.R. Bonsal, W.D. Hogg, “Homogenized daily temperatures over Canada”, J. Climate, in press (2002). [4] É. Mekis, and W.D. Hogg, “Rehabilitation and analysis of Canadian daily precipitation time series”, Atmos.-Ocean, 37, 53-85 (1999).

3-D-2.1

Sensitivity study of low-level cloud albedo resulting from variations in sources of sulfate emissions with NARCM.

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Atmospheric aerosols play an undeniable role in climate regulation. Aerosols absorb and diffuse radiation (direct effect) an act as cloud condensation nuclei (CCN) (indirect effect). When acting as CCN, aerosols affect the cloud droplet number concentration, the albedo and the lifetime of warm clouds. The negative forcing from these combined effects are believed to be of the same magnitude but opposite in sign to the global warming caused by anthropogenic greenhouse gases. In the pursuit of the quantitative determination of the indirect effect of DMS and anthropogenic sulfate aerosols, a regional climate model (NARCM) is used to study the relative contribution of the two major sulfate aerosols sources to the albedo of low-level clouds. The simulations are made for the month of april 1985, in the North Atlantic Ocean. The sulfate sources include anthropogenic sulfur dioxide (SO2), particulate sulfate (H2SO4) and dimethylsulfide (DMS) sea surface concentrations. Falkowski *et al*.*, (1992) found a qualitative relationship between anthropogenic sulfate emissions (inventory data), chlorophyll concentration and enhanced albedo (satellite data) in various region of the North Atlantic Ocean. Our albedo of low-level clouds show a comparable spatial distribution of maximum albedo, when compared with Falkowski's results. In order to quantify the relationship found by Falkowski, fields like temperature, relative humidity, cloud cover and cloud albedo are compared statistically (monthly mean, variance) for two different simulations. The first simulation has both sulfate emissions sources (anthropogenic and natural) while the second one has only the anthropogenic sulfate source. The level of confidence of discrepancies is evaluated to physical explanation.

Falkowski, P.G., Yongseung, K., Zbigniew, K., Wilson, C., Creighton, W. and Cess R., 1992, Natural versus anthropogenic factors affecting low-level cloud albedo over the North Atlantic, *Science*, 256, 1311-1313.

3-D-2.2

The Absorption of NIR Radiation by Precipitating Water Drops

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Laboratory measurements of a cell demonstrates that 1 mm of liquid water strongly absorbs NIR radiation from 1000 to 3000 nm. An experiment with a spray of water droplets about 1 mm diameter demonstrates that water droplets strongly absorb the same NIR bands as a cell of water. We also have observed the spectrum of liquid water absorption in the transmission spectrum of drizzling fog, whereas dry fog does not show any significant absorption. Clouds have a composition similar to fog, suggesting that drizzle in clouds will cause absorption. The absorption fingerprint of drizzling cloud transmission spectra matches the spectrum of liquid water. The same spectral signature of liquid water in the cloud NIR absorption has been observed from an aircraft during the AIRS project in January 2000. The spectral signature of ice was also observed on the same clouds. The presence of large droplets in precipitating clouds is evidenced by the formation of rainbows. Liquid water absorption features are not explained by Mie theory for cloud droplets in the size range from 10 to 20 microns. The absorption cannot be simulated using current radiation codes. We postulate that the liquid water in the form of drizzle in clouds absorbs NIR solar radiation. The effect is associated with precipitating

clouds and includes Virga in many clouds which does not reach the ground. An explanation is that in clouds there is a population of water droplets with radii > 200 microns causing NIR absorption; drizzle consists of droplets around 500 microns. This large droplet population was observed in some of the in-situ particle size distribution measurements during the AIRS project. Indeed, spectral measurements with FTIR spectroscopy of the transmission of solar infrared radiation through clear and cloudy skies has indicated that drizzling clouds absorb unexpectedly large amounts of near-infrared (NIR) radiation.

3-D-2.3

Numeric simulation of pollen clouds in the region of Montreal using NARCM

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During the flowering period, Ambrosia (Ragweed) pollen is responsible for human allergies in the population and constitute an important health issue. The management and, eventually, a control of emission sources requires a good knowledge of the features of these anemophily grains. In fact, pollen is a relatively simple case of aerosol to simulate. Since the particle size is monodispersed and the emission sources are well documented, it becomes an ideal candidate for testing the model and helping to assess measurements and impacts on human activities. In this study, we simulated the emission, transport, and deposition of Ambrosia pollen in Montreal region and compare the results to field observations. Although the number concentration is much smaller than most other aerosol, their detection and allergic effects are very sensitive. They are an excellent tracer for evaluation of aerosol. They permit to examine the development of the urban boundary layer and the role of mixing and resolved convection over warm water bodies. In light of these results, we can propose interpretations of observed features and help managing the air quality at regional and urban scales.

3-D-2.4

Development of a Double-moment Bulk Microphysics Scheme

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As the horizontal resolution of operational NWP models continuous to increase, the models begin to fully resolve even relatively small-scale convective elements. The closure assumptions in convective parameterization schemes become less valid and it becomes appropriate to use condensation schemes that operate only when there is grid-scale saturation. Consequently, explicit microphysics schemes are playing an increasingly important role in operational NWP. Schemes that predict only the mass mixing ratio of the hydrometeor categories are called “single-moment” bulk schemes. For example, the Kong-Yau (1997) scheme describes the raindrop spectrum by assuming a Marshall-Palmer distribution of the drop spectrum with a fixed intercept parameter, No. Although single-moment schemes are computationally efficient, there are some severe limitations imposed by diagnosing, rather than predicting, the total number concentration. Despite the added computational cost of predicting one more variable, allowing both the mass mixing ratios and the total concentrations of each particle type to vary independently – the double-moment approach – results in some significant improvements over the single-moment method. We have developed a six-hydrometeor-category double-moment bulk microphysics scheme which is being implemented into a mesoscale model (MC2). Ultimate, the goal of the research is to demonstrate the ability of the scheme to predict hail sizes in high-resolution simulations of real hailstorms. We demonstrate here the advantages of the double-moment approach in the simple framework of kinematic models. Using a 2-D model with a prescribed flow field, we show that rain rates, drop sizes and radar reflectivity of a Hawaiian rain shower are better simulated using the double-moment scheme. The full microphysics scheme (including ice-phase processes) is then demonstrated using a 1-D kinematic model with a prescribed updraft profile.

Kong, F. and M.K. Yau, 1997: "An explicit approach to microphysics in MC2" Atmosphere-Ocean 35(3), 257-291

3-D-2.5

Numerical sensitivity tests of the Barker-Marshak broken-cloud field optical depth retrieval algorithm

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Reliable optical depth estimates of broken clouds are hindered by the assumption of one-dimensional horizontal radiative transfer. The algorithm proposed by Barker and Marshak (2001) overcomes this difficulty by using spectral differences between radiometric data collected at the surface. This algorithm has been subject to several sensitivity tests. These include the impacts of droplet phase function, uncertainties in specification of effective local surface albedo, instrument noise, and presence of aerosol. While idealized phase functions make for simpler numerical simulations as well as parameterization, they do not occur in nature. Since multiple reflections between surface and cloud are used, local effective spectral surface albedos are needed; point albedos are often insufficient. Unlike models, real data contain noise that cannot, in practice, be made arbitrarily small. Since aerosol is ubiquitous, its variable mark is left on all radiometric quantities. Uncertainties in all these factors affect estimates of cloud optical depth. A Monte Carlo photon transport model, cloud-resolving model data and surface albedo data from satellite observations were used to investigate the impact of these sources of potential error. REF.: Barker, H. W., and A. Marshak, 2001: Inferring optical depth of broken clouds above green vegetation using surface solar radiometric measurements. J. Atmos. Sci., 58, 2989-3006.

3-D-3.1

Update on the Atlantic Environmental Prediction Research Initiative

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The coupled numerical modelling group at Recherche en prévision numérique (RPN) is supporting research and development for environmental prediction based on coupling a variety of numerical prediction models. Much of this is being accomplished through the Atlantic Environmental Prediction Research Initiative (AEPRI) in Halifax, Nova Scotia, in collaboration with other government, industry, and academic partners. Significant progress has been made in projects particularly in collaboration with the Meteorological Service of Canada (MSC) - Atlantic and the Oceanography Department of Dalhousie University (Dal). The main ongoing coupled modelling and AEPRI sub-projects are: atmosphere-ocean coupling via the NSERC/MARTEC/AES Industrial Research Chair in "Regional Ocean Modelling and Prediction" in the Oceanography Department at Dal, coupling data assimilation and prediction systems for coastal applications, modelling the extratropical transition of hurricanes and typhoons, coupled atmosphere-wave models, coupled atmosphere/land-surface/hydrology models, coupling with estuary models, and developing expert systems for marine applications. Numerous Environment Canada (EC) scientists have gained valuable experience and made significant progress in projects in the areas of storm surge prediction, improved oil spill trajectory modelling, wave modelling, severe weather prediction, and streamflow prediction, including preparing some new and innovative forecast products which have been implemented. AEPRI is becoming even more inter-disciplinary and is integrating activities amongst EC's various sectors. For example, the SLICK oil spill model is being used to give support to a project to study birds oiled at sea, and the AEPRI partners are principal investigators in projects on the prediction and mitigation of coastal flooding, as well as for a coupled atmosphere /ocean / biological / chemical observing and prediction system to study pollution in coastal inlets. This presentation gives a status report, including results from several of the sub-projects not represented elsewhere in this Congress, and outlines plans for the future.

3-D-3.2

Empirical Normal Mode Analysis of a Simulated Hurricane

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The theory of empirical normal modes (ENMs) was applied to diagnose inner spiral bands formed in an explicitly simulated hurricane using the high-resolution PSU-NCAR nonhydrostatic mesoscale model (MM5). The ENM method has the capability to decompose simultaneously wind and thermal fields into dynamical consistent and orthogonal modes with respect to wave-activities. For wavenumber one and two anomalies, it was found that the leading modes are vortex Rossby waves, some propagate retrogressively and others propagate progressively due to changing sign of the radial gradient of the basic state potential vorticity (PV). These modes explain 85% of the statistical variances in a period of 24 hours. The Eliassen-Palm (EP) flux and its divergence show that the vortex Rossby waves are concentrated in the inner-core region where the radial gradient of the basic state PV is large. In general, these wave activities

propagate outward in the lower troposphere and inward in the upper troposphere. Consequently, they transport eddy momentum radially inward and outward, respectively. The wave activities also propagate slowly upward inside the eyewall and downward outside. The associated eddy heat transport tends to warm the air in the eye region. The vortex Rossby waves lead to, through wave-mean-flow interaction indicated by the divergence of the EP flux, the acceleration of the mean tangential wind in the lower and middle troposphere inside and outside the eyewall and the deceleration aloft in the eyewall region.

3-D-3.3

Influence of the Downstream State on Extratropical Transition: Hurricane Earl (1998) Case Study

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The extratropical transition (ET) of hurricanes in the western North Atlantic Ocean poses problems for operational forecasters and researchers alike. Complex interactions between the remnant tropical vortex and midlatitude upper-level disturbances result in low predictive skill and complicated diagnoses. The research presented here quantifies the influence of features downstream of the transitioning cyclone on the ET and reintensification process. A more complete understanding of the dynamics associated with these events is crucial to enhancing their predictability and will prove extremely valuable to inhabitants of the North American eastern, who can be severely affected by transitioning storms. Typical Cape Verde hurricanes move westward across the equatorial Atlantic and curve northward near the Caribbean or in the Gulf of Mexico. Subsequent weakening can be attributed to the combined effects of cooler surface temperatures, reduced moisture supply, and increased vertical wind shear. Often, the ex-tropical system dissipates rapidly during recurvature. However, some systems (approximately 25% in the western Pacific Ocean) undergo ET and reintensify rapidly at latitudes as high as 50oN. The presence of an upstream trough has been shown to be necessary for such a rapid redevelopment since it connects typical midlatitude quasigeostrophic forcings with the moist lower-level ex-hurricane dynamics. The nature of the interaction between the tropical and extratropical features, however, is modulated to a certain extent by the atmospheric state downstream of the transitioning system. Two modes of ET and reintensification have been analyzed during a double-transition event that occurred in September 1998. Hurricane Earl transitioned to an intense baroclinic system in the western North Atlantic; simultaneously, Hurricane Danielle underwent a tropical mode of reintensification in the eastern section of the basin. Dynamic tropopause maps highlight the structural differences associated with the distinct baroclinic and tropical modes of ET and reintensification. In the baroclinic mode, cyclonic potential vorticity (PV) rollup at upper levels aids in the deformation of a near-surface baroclinic zone and associated frontogenesis. The tropical mode is characterized by strong warm advection ahead of and around the core of the system. The isolation of the warm, moist tropical air within 1000~km of the center by stratospheric PV streamers reduces mixing with the cooler surrounding and provides a locally tropical environment during the storm's redevelopment. It is shown that the presence of a downstream jet/front structure is necessary for baroclinic mode reintensification. The location of the transitioning storm in the entrance or exit to the zonal jet proves to be the crucial factor in determining what mode of reintensification will occur.

3-D-4.1

SCRIBE/marine

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A prototype version of SCRIBE/marine capable of plain language marine forecasts (Quebec region style), MAFOR and NAVTEX has been developed. SCRIBE/marine is the result of a joint collaboration between the Canadian Meteorological Centre and the Meteorological Service of Canada - Quebec Region, in an effort to address the problem of generating marine forecasts for the St-Lawrence River seaway and to facilitate the production of NAVTEX and MAFOR forecasts. A project has been set-up to use this prototype version as the platform to build a national version of SCRIBE/marine capable of generating all marine forecasts under the responsibility of the Meteorological Service of Canada. SCRIBE/marine is being developed in the same framework as the public counterpart A new set of rules has been added to the SCRIBE knowledge base and the graphical user interface has been modified in order to deal with the marine aspect of the problem. Using the public version of SCRIBE as a platform makes it easier to include new regions, maintain a weather watch on the marine forecast, verify the marine forecast and generate new product, either in graphical or textual format. SCRIBE/marine puts emphasis on wind and wave forecasting over water. Different strategies to resolve these issues will be explored. The functionality of SCRIBE/marine will be presented and examples of marine forecast products will be shown.

3-D-4.2

Wind and wave forecast verification

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Since 1995 the Canadian Meteorological Centre (CMC) carries verification of the objective wind and wave forecasts as extracted from the operational Regional model (for winds) and the operational Atlantic Wave Model (for the wave parameters). The verifying observations are taken from marine stations such as ships, drilling platforms, fixed and drifting buoys available in a specific area covering mostly the Gulf of St-Lawrence. The observations are collected over a time window of two hours and thirty minutes on either side of the four main synoptic hours (00, 06, 12 and 18 UTC). These observations are not quality controlled. The operational Regional model output used for verification are winds at the lowest level in the model, which are considered to be the ten meter winds. The wave forecasts data come from the operational wave model. The wave period and wave height are the parameters verified. The 0- to 48-h forecasts, valid at the synoptic hours are considered for the verification purpose. Usual scores are computed for the wind speed and direction and also for the wave parameters (wave height and period). These scores include amongst others: bias (mean error), mean absolute error, root mean square error, true root mean square error, mean and standard deviation. Verification results will be presented.

3-D-4.3

Springtime Gale Force Northeast Winds over the St. Lawrence River

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On May 11th 1998, 30- to 45-knot northeast winds developed between Quebec city and Pointe-des-Monts, while 20- to 25-knot winds blew elsewhere over the St. Lawrence River. These strong winds were unusual and unexpected as they quickly developed in the

early morning under the approach of a broad surface anticyclone. After looking back at 55 similar synoptic patterns in previous springs, it was found that northeast winds were consistently underforecast. A detailed analysis of the May 11th case revealed that differential heating between the cold St. Lawrence waters and the surrounding land (mainly the Gaspé peninsula) was the main driving force in generating these strong winds. As temperatures rose to near 20°C inland due to daytime heating and stayed near 8°C over water, a sharp mesoscale thermal trough rapidly developed over the Gaspé peninsula. Additionally, the anticyclone approaching from Labrador towards Anticosti Island caused MSL pressures to rise over the cold waters; but land heating was strong enough that MSL pressures were falling on most areas surrounding the St. Lawrence. As a result, both isobaric and isallobaric gradients were significantly enhanced, explaining the unusually strong winds observed that day. Under fair weather, significantly underforecast winds have a strong impact on a lot of marine users, especially those using small crafts (e.g. sea kayaks, sailboats, ...), specifically waiting for such conditions (i.e. sunshine, mild air temperatures and light to moderate winds) to go out on the water. Through pattern recognition and with the help of a recently developed statistical forecast tool, local operational marine forecasters have learned to better warn their users about these types of events.

3-D-4.4

Development of Surface Wave Forecasting for GoMOOS

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The Gulf of Maine Ocean Observing System (GoMOOS, http://www.gomoos.org) has sponsored the development of a state-of- the-art surface wave forecasting system to promote the safe and efficient use of Gulf of Maine (GOM) waters. As part of this development, a new implementation of the SWAN (Simulating Waves in the Nearshore environment) wave model was implemented in the GOM. This implementation includes a coarse 1-degree grid for the entire N Atlantic, nested to an intermediate 0.2-degree grid for the NW Atlantic, and finally a fine-resolution 0.1-degree grid for GOM. The latter resolution is about 10 km. These grids and domains correspond to operational WAM implementations as run by the US Navy. Thus, using the same wind fields as WAM, we are able to intercompare the two wave models. Validations of model outputs will be conducted using all available 1-D wave height measurements from GoMOOS and NOAA wave buoys scattered around the GOM, as well as remotely-sensed satellite data from RADARSAT synthetic aperture radar (SAR). In addition, 2-D spectra measured during the winter of 2001/02 will be used to further evaluate the accuracy of model results. The 2-D measurements will be obtained both remotely, with RADARSAT SAR, and directly in shallow (<20 m) waters off Yarmouth N.S., using a directional wave rider buoy and bottom-mounted ADCP. Preliminary results of this project will be described.

3-D-4.5

Validation du modèle de vagues pour le Saint-Laurent

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Des modifications majeures ont été apportées au modèle communautaire WAM afin d'introduire dans ce dernier les effets des courants et des glaces. La généralisation du code du modèle a été faite de façon à ce que dernier soit exécutable sur n'importe quel domaine et spécialement sur des domaines où il y a une forte influence temporelle et spatiale: des courants marins locaux, que des variations significatives des niveaux d'eau et lieu où il y a génération de vagues. La version actuelle du modèle WAM que nous utilisons est la version du groupe "PROMISE" sur une grille à haute résolution (5 km). Cette version fait le couplage dynamique entre les sorties d'un modèle océanique opérationnel et les sorties d'un modèle atmosphérique afin de prédire l'état de la mer pour l'estuaire du Saint-Laurent. La vérification préliminaire des vagues prévues pour les cas étudiés est très encourageantes et démontre l'importance des effets des courants dans l'estuaire du Saint-Laurent et la possibilité d'appliquer le même modèle avec succès dans d'autres lieux.

Major modifications were brought to the community WAM wave model to introduce the effects of the currents and ice. The generalization of the model code was made in order to obtain a model able to produce sea state forecasts on any domain, specifically one in which there is a strong influence of local currents, time-dependent water depth, and changes in the effective fetch on the wave development. Therefore, we actually use a modified version of the recently developed PROMISE version of the WAM model, implemented on a fine-resolution 5 km-grid. This code is capable of interactive coupling between waves and an operational ocean circulation model for these waters. For selected storms, preliminary verifications of the heights of waves forecasts indicate that we obtain encouraging results and that the influence of the currents is important in the estuary of the St-Laurent river. Where available, comparisons are made to the operational MSC WAM model and with in situ or satellite wave measurements. We show that the PROMISE wave model offers potential improvements for simulations of wave heights and wave spectra for these waters.

3-D-4.6

Marine Winds Derived from RADARSAT-1: Results from the Winter 2001-2002 Demonstration Project

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The Canadian Ice Service (CIS), part of the Meteorological Service of Canada (MSC), is responsible for ice information services to marine users operating in Canadian ice covered waters. Although the CIS mission is mainly focused on ice monitoring, recently the role of the CIS has been expanded to include a marine service component. RADARSAT-1 Synthetic Aperture Radar (SAR) imagery is the primary satellite data of the CIS, receiving approximately 4000 scenes annually. The appearance of dramatic atmospheric conditions imprinted on the open water of oceans and lakes, such as, fronts, convective activity, boundary layer rolls, lee waves, and atmospheric gravity waves, has increased interest in using this data for other marine and meteorological applications. It is well known that variations in the radar backscatter along the ocean surface are a function of wind speed and wind direction. Conventional satellite scatterometers currently provide wind information in the 25-50 km range making it difficult to forecast coastal areas due to land contamination. Wind information derived from RADARSAT-1 SAR can theoretically be derived down to the resolution of the beam mode used (in the 10’s of metres range). This is of particular interest to meteorologists,

especially during stormy winter periods in Atlantic Canada and the Great Lakes, where a lack of buoy observations can create data gaps in marine weather forecasting. In an effort to expand the use of RADARSAT-1 imagery within the MSC, a demonstration project was developed for two winter periods (Jan-April, 2001 and 2002). Wind plots were derived from RADARSAT-1 imagery using the Ocean Monitoring Workstation located within the Canadian Ice Service in Ottawa and delivered in a semi-operational manner to MSC marine weather offices in Atlantic Canada and the Great Lakes. Validation results of wind speed and direction will be presented as well as feedback from meteorologists.

4-A-1

Snow, Sea Ice and Arctic Climate Processes

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Arctic climate processes are, in general, poorly understood. One of the complexities in understanding how the arctic will respond to global scale climate variability and change is the role which snow and sea ice play in controlling energy and mass fluxes across the ocean-sea ice-atmosphere (OSA) interface. The snow/sea ice system is significant at a range of time and space scales on how the atmosphere and ocean are coupled throughout the annual cycle. Feedback mechanisms complicate these processes and the timing of particular events can have significant impacts in both the ecological and geophysical characteristics of the system. In this paper I introduce the nature of the Arctic snow/sea ice system from the perspective of thermodynamically and dynamically related processes. Thermodynamic processes dominate ice growth and decay and control metamorphic processes associated with snow on sea ice. Dynamically driven processes control marginal ice zone characteristics while at the same time contributing to ice deformation and ice bridge formation. Both dynamic and thermodynamically driven processes play a central role in controlling the magnitude and timing of radiative and conductive fluxes across the OSA interface and as such also play an important role in marine ecosystem response to climate variability and change. I illustrate the theoretical development of this work with results from field studies in the North Water Polynya and the Canadian Arctic Archipelago. I provide examples of the importance of dynamic and thermodynamically driven processes in these regions; detection of magnitudes and rates relating to selected processes (e.g., ice kinematics, snow metamorphism, sea ice ablation, ice bridge formation, etc); and the integration of field and remote sensing data into numerical process models which are then used to study the sensitivity of sea ice in marine ecosystem and geophysical processes operating within the OSA interface.

4-A-2

Mesoscale mapping of the wind energy potential of Canada

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The low-level wind regimes simulated by the 3-km MC2 mesoscale atmospheric model over central Europe during the 1999 MAP field project was found to be in excellent agreement with the recent European Wind Atlas. A simplified 3D simulation tool, similar to that used in MAP, was developed to compute the wind-energy potential at hub-height of modern wind turbines (50 m a.g.l.), thus enabling a modernized Canadian Wind Atlas and reducing the cost of field deployments for siting. Sample results are presented.

La cartographie du potentiel éolien à la méso-échelle au Canada

Le régime des vents de basse couche simulé par le modèle MC2-3km durant la campagne MAP 1999 sur le centre de l'Europe s'est avéré en bon accord avec l'Atlas Éolien européen. Un outil simplifié de simulation 3D a été développé, similaire à celui pour MAP, pour calculer des potentiels éoliens à l'altitude de nacelle des nouvelles turbines (50 m a.g.l.). Quelques résultats sont présentés, ainsi que la capacité de produire un nouvel Atlas Éolien du Canada, crucial pour la croissance nationale de cette industrie.

4-A-3

The North Water polynya: a window on the changing Arctic Ocean?

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The North Water polynya is perhaps the most productive ecosystem north of the Arctic Circle. It is located at latitudes that will be impacted early and most strongly by climate warming. During expeditions of unprecedented magnitude in 1997, 1998 and 1999, the International North Water Polynya Study (NOW) explored the functioning of this mythical ecosystem. The central hypothesis of NOW was that sensible heat from the ocean causes the early melt of the ice cover along the Greenland Coast, with the resulting stratification triggering an early phytoplankton in April-May. Along the Canadian Coast, wind removes the ice once an ice bridge is formed in Nares Strait (latent-heat formation), and the bloom is delayed until the thermal stratification of the surface layer by solar radiation in June. Modelling and observations indicate that, as a cyclonic circulation drives southern air masses along the Greenland Coast in spring, offshore winds and atmospheric heat, rather than oceanic heat, force the early removal of ice in the eastern North Water. The consequences of this circulation pattern on phytoplankton, copepods, vertebrates, and biogeochemical fluxes are briefly reviewed. The succession of sensible- and latent-heat forcing responsible for the exceptionally long season of biological production in the North Water (up to 5 months) is unlikely to resist major changes in the timing of the formation of the ice bridge and in regional atmospheric circulation. Paradoxically, the North Water could open later and its seasonal duration could shorten as climate warms. The present productivity of the North Water could be an indicator of the biological production and biogeochemical fluxes that will prevail over the extensive Arctic Shelves as the ice cover regresses under climate warming. However, the circum-Arctic flaw polynya system would probably be a better harbinger of climate change in the Arctic Ocean than the North Water.

4-B-1.1

The Simulation of Fortnightly, Deep-Water Exchange in Indian Arm, B.C.

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Burrard Inlet, which opens into the Strait of Georgia off the coast of British Columbia, is about 20 km long, and is never wider than about 4 km or deeper than about 65 m. It has two sills that are both shallower than 20 m. It connects to Indian Arm which is also about 20 km long but has a maximum depth of about 220 m. A numerical model is used to simulate deepwater renewals that were observed to occur in Burrard Inlet/Indian Arm over a time period of about one hundred days during the winter of 1984/85. The renewals (bottom water flowing from Burrard Inlet into Indian Arm) occurred (or intensified) during neap tide and caused a steady increase in the density near the bottom in Indian Arm. The model successfully reproduces the renewal events for a simulation time of at least eighty five days. It uses a Mellor-Yamada, level-2 turbulence closure scheme, for which the local turbulent energy production is balanced by local dissipation, and for which the turbulent length scale is prescribed. The length scale varies linearly with depth near the surface and bottom, and is constrained to never be larger than (1) 20 % of the water depth, and (2) the Ozmidov length scale. A lower bound is imposed on the vertical diffusion coefficients that depends on the Brunt-Vaisala frequency N. Its magnitude, for a given N, is different in Burrard Inlet and in Indian Arm, and it was estimated from observed variations in the scalar fields. When the influence of horizontal variations in the along-channel velocity on the turbulent energy production is taken into account, the model simulates the observations more accurately.

4-B-1.2

Data assimilation in a multi-constituent tidal model

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We assimilated Topex-Poseidon (TP) derived tidal constituents in a baro-tropic finite element model of the Northwest Atlantic. The assimilation system consists of running a forward nonlinear model that computes the actual tidal forecast and an inverse harmonic linear model that optimizes the elevation boundary condition in order to minimize the error relative to the TP data. With this system, we found an overall RMS error of about 1~cm to 2~cm relative to the TP and 2-6~cm relative to coastal tide gauges (excluding the bay of Fundy-Gulf of Maine) depending on the tidal constituent. The main difficulties encountered are found in shallow regions such as the Saint Lawrence estuary, the Northumberland Strait, the Gulf of Maine and the Bay of Fundy where doubts can be raised concerning the dissipative model of the bottom layer. Some difficulties were also experienced in the northern part of the domain, close to the Hudson Strait where the M2 tide reaches large amplitude and where some coastal data would be required to assess the quality of the TP data. The TP data seems to agree with the ground stations in general for all constituents. Finally, we will investigate the relationship between the error in the model and the length of the tidal record in order to estimate the quality of the coastal data.

4-B-1.3

Winter Water Masses in the Gulf of St. Lawrence from CTD Surveys since 1996

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The near-freezing surface layer that is found in the gulf of St. Lawrence in wintertime was sampled in early March since 1996. Its thickness varies geographically but usually exceeds 100 meters in the northern gulf, and has been observed to exceed 200 meters in 2001. This cold layer contributes heavily to the regeneration of the Cold Intermediate Layer (CIL) that will prevail during the following summer. The cold surface layer is created locally from convection (associated with ice formation) supplemented from varying amounts of advected waters from the strait of Belle-Isle. Varying amounts of warmer water also enter the gulf from the eastern side of Cabot Strait. The amounts and characteristics of the various water masses found each year are described and are compared to CIL conditions found the following summer.

4-B-1.4

Internal Solitary Wave Overturning and Run-Up on the Slope of an Island: A Case Study in the St. Lawrence Estuary

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The surface signature of internal solitary wavetrains was observed in the North Channel of the St. Lawrence Estuary using a shore-based time-lapse camera. Waves were observed on 4 different days and always appeared at the same tidal phase. This indicates that they were generated by the tidal flow. The generation site of the waves is uncertain but their destination is known: they collide almost perpendicularly with the slope of Île-aux-Lièvres island. In order to examine the wave-boundary interaction we developed a 2D non-hydrostatic numerical model. Using this model, with realistic topography and idealized stratification, we found that internal solitary waves approaching the island will overturn and break on the slope region. This produces vertical turbulent fluxes of salt, heat, and presumably nutrients. At the same time, the wave-boundary interaction induces "run-up", i.e. up-slope advection of dense water. The shear associated with this run-up produces overturning and further mixing. The results of this study suggest that mixing and transport from internal solitary waves may contribute to the previously-reported enhanced biological activity near the Île-aux-Lièvres island.

4-B-1.5

Ocean Surges over the Nigerian Coast: A Case Study of the Victoria Island Beach Flooding and Erosion

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The threat imposed by ocean surges and associated flood over the low-lying coast of Nigeria particularly that of Victoria Island is becoming unbearable. It has caused the contamination of coastal water resources, decimation of coastal agricultural and recreational areas, destruction of settlement, major road like Amadu bello way, harbour and navigational structures. It has also dislodged oil producing and export handling facilities and environmental impact of loss of properties, income and sometimes lives. Statistical analysis and parametric wave model have been used for the period 1990 - 2001 to investigate the ocean-atmosphere interactions. It revealed that these surges are experienced in the months of April - October, but more frequent in August, when the prevailing southwesterly winds are consistent. Coastal pressure are transiently low except in August and May 2001 events. Also within the period under study low pressure always coincides with high spring tides. Further investigations revealed that the ocean surge are

influence by winds between 15 and 20kts in strength over the fetch area (Lat. 10oS - 20os and Long. 0o - 10oE). These winds generate wave height between 1.2 - 2.8m using the parametric wave model and with favourable cross-equatorial flow, it takes the wave 2 -4 days to reach the coast as swells capable to inundate the coast.

4-B-1.6

Northerly Storms and Sediment Plumes in Lake Michigan

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The satellite images has revealed episodic late winter-spring sediment plumes coinciding with northerly storms in southern Lake Michigan. A major inter-disciplinary observational program (Episodic Events Great Lakes Experiment, EEGLE) was initiated by NSF and NOAA to study the importance of these episodic events on the cross-margin transport and subsequent ecological consequences. As a part of EEGLE program instrumented moorings were deployed during the winters of 1998-2000 in Lake Michigan. The time series data of winds, currents, and temperature were analyzed to provide the description of the coastal flow and cross-shore exchange characteristics in southern Lake Michigan. The data shows several current reversals coupled with changes in surface wind stress. The observations also show the signature of forced two-gyre circulation in the southern basin. The low pass filtered currents for the winter season shows significantly higher alongshore currents compared to cross-shore flow, however, during northerly storm events offshore flow increased at a few locations. Northerly storm episodes depict a slightly higher horizontal turbulent exchanges and increased vertical current shear in comparison to the overall winter conditions.

4-B-2.1

A study of heavy precipitation occurring in continental and marine environments

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This research focuses on the physical processes relating to two recent events of precipitation in which at least 25 mm of liquid equivalent precipitation occurred within a 12Ðh period. The first event was that of the heavy snow in Albany, New York of 7 January 2002, and the second event was that of a heavy snow in Halifax, Nova Scotia of 4-5 February 2002. Each event was evidently unrelated to topographic forcing. Each case was also mostly unforecasted by the operational models with horizontal resolutions ranging to 6 km. Although each case occurred in a large-scale flow that was favorable for cyclogenesis, several crucial details relating to the extreme mesoscale development are identified and studied. Additionally, cyclogenetic mechanisms are studied. The mesoscale environment is studied in the context of both upright and slantwise convection. The processes that were responsible for this destabilization include upper-level cooling associated with the advance of an upper-level short-wave trough, and the development of conditional symmetric instability. Frontogenetic forcing was especially large in the middle troposphere in each case. The fact that ascent maxima of Ð20 to Ð50 microbars per second occurred in the vicinity of these zones of frontogenesis suggest the importance of this forcing contributing to these events strength. Considering that the upper-level frontogenesis was associated with a sloping dynamic tropopause, we investigate the role of the diabatically-induced effects of the observed moist convection in each case. To do this, we use a high-resolution version of the Mesoscale Compressible Community Model (MC2) with an accurate microphysical parameterization and explicit representation of cumulus effects. We investigate the hypothesis that moist upright convection produces a positive feedback on surface cyclogenesis through the mechanism of diabatically-induced ridging. This ridging shortens the wavelength, and increases the cyclonic vorticity advection over the developing cyclone.

4-B-2.2

The Effects of Lake Breezes On Weather (ELBOW) 2001: Project Overview and Preliminary Results

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The Effects of Lake Breezes On Weather (ELBOW) 2001 is a project to investigate the relationships between lake breezes and severe weather, including heavy rain, hail and tornadoes, in southwestern Ontario. Stable marine air generally suppresses convective activity in areas downwind of the Great Lakes. However, the leading edge of the lake breeze, called the *lake breeze front*, is a zone of enhanced moisture, lift, shear and

vorticity that can act to trigger the development of thunderstorms in a convectively unstable environment. This is especially true when lake breeze fronts interact or when they collide with other low-level boundaries such as thunderstorm gust fronts. Southwestern Ontario, surrounded by lakes on three sides, is an ideal location for such a study. Project participants include York University, the Meteorological Service of Canada, University of Western Ontario, University of Guelph - Ridgetown College and the Weather Network. A field campaign was undertaken between June and August of 2001 that made use of observation platforms such as the NRC Twin Otter research aircraft, a 14 station mesonet, 4 rawinsonde systems, two wind profilers, a portable Doppler radar and mobile observation equipment. These platforms were located within the effective Doppler range of the Environment Canada operational weather radar located in Exeter, north of London, since this radar is well suited for detecting low-level boundaries in optically-clear air. A version of the GEM model with 2.5 km horizontal grid spacing was also run in real-time in support of the experiment. Summer 2001 was hot and unusually dry resulting in frequent lake breezes but little in the way of severe weather. However, a number of events of interest were captured. The data from this study are now being analyzed and some preliminary results will be presented. It is expected that this project will contribute to improvements in severe weather watches and warnings for this region.

4-B-2.3

The Use of the GEM Forecast Model at very high resolution during ELBOW 2001

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The Effects of Lake Breezes On Weather (ELBOW) 2001 was held in southwestern Ontario during June to August of 2001. Its purpose was to study the role of lake breezes in triggering convection and, in particular, the strong convection which can result in hail, heavy rain and tornadoes. A mesoscale network was installed to supplement the regular surface network. On intensive observing days serial radiosondes were launched from 3 sites, mobile observations were taken and the NRC Twin Otter flew transects on a line similar to that of the radiosondes. As part of its support to the project the Canadian Meteorological Centre provided special runs of the GEM model with a horizontal grid spacing of 2.5 km. The model was run in a non-hydrostatic mode and no convection parameterization was used. These model runs were used in conjunction with the regional GEM model and other mesoscale models to plan activities during the project. GEM 2.5 provided useful estimates of lake breeze locations and possible interactions between lake breezes and with fronts. We will use case studies to illustrate some of the strengths and weaknesses of these forecasts and discuss some implications for severe summer weather forecasting. In particular, we will show a case in which storm outflows interact with topographically induced boundaries resulting in "backbuilding" of the storms. Some of these storms produced heavy precipitation although no precipitation was forecast by the regional GEM model. GEM 2.5 forecast the sequence of events in this case but the timing was inaccurate.

4-B-2.4

Synoptic-scale signatures of warm-season mesoscale vortices in the Montreal region.

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Two classes of precipitation systems in Southern Quebec have been selected: a) 27 intense thunderstorms associated with mesocyclones and b) 26 less intense thunderstorms without mesocyclones (used as a control set). The objectives of this research are to document characteristic synoptic flow patterns accompanying warm-season (May through September) precipitating events associated with mesoscale vortices, and to isolate moisture transport flow anomalies. The first objective is accomplished through a 27-case 500-mb height field composite spanning the years 1993-99 and a comparison between the later and the 26-case 500-mb height field composite spanning the years 1993-96. In addition, an analysis of pressure and potential temperature along the dynamic tropopause (here defined as a surface of constant potential vorticity, thereafter PV) allows for a simple representation of the upper-tropospheric flow. The second objective is addressed through diagnosis of the precipitable water content composite of the two sets of cases. It appears that the 27 thunderstorms associated with mesocyclones show an organized flow pattern well before the onset time of the events. Also, the 500-mb height anomalies can be tracked several days in advance of the events out to at least 3 days. From the composite maps of , it features that for the 27 mesocyclones, the Pacific and later the Atlantic Oceans participate to the build up of the warm pool anomaly over the Great Lakes, whereas only the Atlantic Ocean plays a similar role for the 26 thunderstorms. The strong precursors of coherent dynamic tropopause forcing seen several days in advance for the mesoscyclones are not as apparent in the thunderstorm sample. From well in advance until the onset time of the 27 events, the Atlantic Ocean, the Gulf of Mexico and the Great Lakes form a wide and active area feeding up the systems in moisture. In opposite, a less broad area of moisture content seems to be picked up to create the less intense 26 thunderstorms.

4-B-2.5

Summer Severe Weather Climatology for Southern Ontario: A Doppler Radar Perspective.

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A methodology has been developed for creating a severe weather climatology from radar related products. The Universal Radar Processor (URP) software recently implemented as part of MSC's National Radar Project (NRP) has been used to process the King City radar data archive which extends back to September 1988. Radar parameters of particular interest are: severe weather (storm areas where Ze > 40 dBZ and extend above 5.5 km), mesocyclone occurrence (detection of rotation signatures in the Doppler velocity fields), and VIL (Z converted to liquid equivalent and vertically integrated through the entire radar volume). These parameters were examined to determine their ability to identify severe weather. Observations of severe weather events within the King radar coverage by the Regional Center Toronto (RCTO) were used to tune the algorithm thresholds. An important result is the range dependence of the mesocyclone detection algorithm. Beyond 60 km from the radar, its ability to detect tornadic signatures is dramatically reduced. URP's new Cell Identification and Cell Tracker modules have been applied to the derived radar parameters to give temporal and spatial distributions of the severe weather events. Conceptual models of the temporal and spatial dependence of severe weather on geography, convective instability, and dynamic forcing are emerging from this analysis. Additionally, the year-to-year variation is being examined and related to larger scale planetary scale precursors to severe weather. This methodology can be applied to any radar, of the MSC Doppler radar network. One example is the Doppler radar installed at Exeter, Ontario, in 2000. A comparison of results from the summers of 2000 and 2001 between the Exeter and

King City radars is showing important benefits in using the adjacent radars in a constructive sense to make composite depictions of severe weather events.

4-B-3.1

La tête du chenal Laurentien dans l'estuaire du Saint-Laurent: un habitat critique nordique de concentration et d'agrégation de la nourriture des rorquals

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La tête du chenal Laurentien dans l'estuaire du Saint-Laurent est le site d'un intense upwelling régulier d'eaux de la nappe intermédiaire froide, résultant de l'interaction de la marée barotropique avec la topographie sous-marine. La dynamique océanographique particulière de cette zone est responsable de la création d'une zone privilégiée par les baleines pour s'alimenter depuis des siècles. On y retrouve la plus riche agrégation de krill documentée à ce jour pour le Nord-Ouest de l'Atlantique. Celle-ci résulte du pompage des eaux intermédiaires par la circulation estuarienne, combiné à l'intense upwelling et le phototactisme négatif du krill. La biomasse de cette agrégation est dominée par une espèce d'euphausiacé associée aux eaux froides. L'intense upwelling tidal est aussi impliqué dans la concentration d'un petit poisson pélagique d'eau froide, le capelan, le long des talus à la tête du chenal pendant le flot, de même que le long des fronts qui se forment aux interfaces entre les masses d'eaux. Cette concentration cyclique du capelan par la circulation semi-diurne est mise à profit par les rorquals pour s'alimenter. Les deux types de proies principales des rorquals sont des espèces d'eau froide et par conséquent susceptibles d'être affectées par les changements climatiques. Les débits d'eau douce du Saint-Laurent et la stratification dans la région des seuils qui contrôlent la dynamique de pompage des eaux intermédiaires sont également deux variables susceptibles d'être affectées par des variations climatiques. Cet habitat critique nordique à la tête du chenal principal du plateau continental canadien dans l'Atlantique, qui fait maintenant partie du Parc Marin Saguenay—Saint-Laurent, est donc vulnérable aux changements climatiques.

4-B-3.2

The role of precipitation, river run-off, and wind on toxic algal blooms in the St. Lawrence (1989-1998)

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Since harmful algal blooms are closely tied to their surrounding environmental conditions, variations in climate may potentially influence their distribution and bloom dynamics. The role of climate variability on blooms of the toxic dinoflagellate *Alexandrium tamarense*, responsible for paralytic shellfish poisoning, was analyzed over a 10-year period (1989-1998) at Sept-Îles, in the northwestern Gulf of St. Lawrence. Hydrological and meteorological data for the region indicate that rainfall, local river run-off and wind are highly related with the pattern of bloom development each year. Results from the 10-year data set reveal that in this system: 1) high river run-off from a prolonged spring freshet or from heavy rainfall events in the summer and fall can initiate *A. tamarense* blooms, 2) high river run-off combined with prolonged periods of weak winds ($<4\ m\cdot s^{1}$) favor the continued development of blooms, and 3) winds $>8\ m\cdot s^{1}$ disrupt blooms. Salinity, which reflects the general state of the water column in terms of freshwater input and stability, was strongly and negatively correlated with the probability of observing *A. tamarense* cells at this station and could thus be used as a predictive tool for the presence of cells in this system.

4-B-3.3

Linking Phytoplankton Bloom, Copepod Egg Production, Naupliar Survival and Recruitment in the North Water Polynya

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We test the hypothesis that the different spawning strategies of herbivorous calanoid copepods in Arctic waters have evolved to match the first-feeding naupliar stages with the onset of the phytoplankton bloom. Female abundance, egg production rates, in situ abundance of eggs, nauplii and CI copepodites were monitored from early April to the end of July in the North Water polynya (northern Baffin Bay). Copepod reproduction dynamics are compared between the Ellesmere and Greenland sectors of the polynya where distinct temperature and phytoplankton biomass regimes prevailed in 1998. The phytoplankton bloom and Calanus glacialis female abundance and egg production started earlier in the Greenland than the Ellesmere sector. However, the abundance of naupliar stages did not differ between the two regions, survival to copepodite CI was actually better in the Ellesmere sector. While superior food conditions triggered an earlier and more intense egg production along Greenland, higher summer temperatures along Ellesmere produced an overall better survival to CI. The implications of warmer temperatures in the polynya are further studied by comparing the timing of copepodite recruitment and population development between the North Water and Barrow Strait, a non-polynya region in the Canadian Archipelago. The phytoplankton bloom and the recruitment of the first cohort of copepodites of *Calanus hyperboreus*, *C. glacialis*, and *Pseudocalanus spp.* started in May/June in the polynya, some 1.5 to 3 months earlier than in Barrow Strait. Consistent with a precocious summer recruitment, population stage structure of these species in early spring (April-May) was more advanced in the North Water than in Barrow Strait. Climate-induced reduction of ice cover duration is predicted to favour the population growth of the predominant large calanoid copepods and Pseudocalanus on Arctic shelves.

4-B-3.4

Interannual variability (1947-2001) of the cold intermediate layer in the Gulf of St. Lawrence: thickness and core temperature

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Temperature and salinity data from a public database were analysed to investigate the interannual to interdecadal variability of the thickness and core temperature of the cold intermediate layer in the Gulf of St. Lawrence. A new spatially dependent 1971-2000 climatology of these two properties is also derived. We find that the CIL thickness ($T < 1$ °C) is negatively correlated with CIL core temperature ($r = -0.88$), and this relationship remains highly significant even when accounting for serial correlation in the time series. We will also show that CIL thickness is related to CIL volume by using a shorter 1985-1998 time series of CIL volume estimated from temperature data collected during synoptic groundfish surveys. Finally, we will discuss what are the likely forcing mechanisms driving CIL interannual variability.

4-B-4.1

Facing a large increase in wind energy projects in Canada: the requierements from the industry and the new trends in weather forecasting and wind measurements

Jean-Louis Chaumel

4-B-4.2

Climate change in Hudson Bay, James Bay and Foxe Basin: Trends and projections.

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This paper examines the climatic (temperature and precipitation), hydrological and lake and sea ice thickness records of the past century in an attempt to detect climate change signals in the greater Hudson Bay region. Most weather stations have experienced a warming trend in winter, summer, and spring, whereas cooling trends were detected West and South of Hudson Bay in the autumn. Over the same time period, precipitation has increased during all seasons. The Mann-Kendall test reveals a statistically significant trend towards an earlier occurrence of the spring freshet South of Hudson Bay, a region with a significant warming trend in spring. Northwest of Hudson Bay, streamflow has significantly increased during all seasons, a trend in agreement with the precipitation record. In Manitoba, precipitation has increased from 1920 to 1970 but it has been decreasing since then. The decrease in precipitation during the last three decades and increased evapotranspiration due to warmer temperatures explain the decrease in river discharge since 1970 in that region. East of Hudson Bay, no temporally nor spatially coherent climate change signals were identified. Also, an analysis of the lake and sea ice thickness records reveals that the maximum ice thickness has significantly increased at a few measuring stations around Hudson Bay. A trend towards more abundant snowfall explains the consistency of the trend towards a thicker ice cover over both the lakes and the inland seas. In addition, the outputs of six coupled general circulation models are presented. The ability of the models to simulate the present climate of Hudson Bay is evaluated. Then, the climate change scenarios projected under a 2xCO2 scenario are compared with the observed secular trends of the past century.

4-B-4.3

Vulnerabilities to Climate Change in Canada

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Canada is vulnerable to climate change in many areas. Assessment of this vulnerability is critical in determining policy response to this issue. Understanding of potential impacts alone is insufficient for such assessment. Rather, the critical elements are the climatic sensitivity and the adaptability of the system under consideration. This requires a thorough understanding of nature and dynamics of the system under study, including recognition of thresholds and response times. A system may be highly sensitive to climate change, but if it is also highly adaptable, its vulnerability may be relatively low.

A focus on vulnerability is being advocated by the Government of Canada's Impacts and Adaptation Research Program. In addition to providing financial support for climate

change research across a wide range of sectors, the program also facilitates interaction between researchers and stakeholders through the Canadian Climate Impacts and Adaptation Research Network (C-CIARN). C-CIARN is a partnership of governments, universities, industry and other decision-makers and is made up of six Regions - British Columbia, Prairies, Ontario, Quebec, Atlantic and North, and seven Sectors - Health, Landscape Hazards, Coastal Zone, Fisheries, Agriculture, Water Resources, and Forest. A coordinating office at an educational institution or Federal government office manages each Region and Sector.

4-B-4.4

Fluctuations de la température dans le Grand Nord du Canada pendant la période 1941-2000

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L'Arctique canadien est une région sensible aux changements climatiques. D'après la théorie de l'effet de serre, c'est une des régions où le réchauffement devrait être le plus marqué. L'analyse de la température d'une douzaine de stations du Grand Nord (latitude > 60ºN) permet de vérifier cette hypothèse. Les stations analysées sont: Cap Dyer, Clyde et Iqualuit dans l'Est; Cambridge Bay, Coral Harbour, Eureka, Hall Beach et Resolute dans la partie centrale (80º< longitude <115ºO); Alert, Isachsen, Mauld Bay et Sachs Harbour au bord de l'Océan Arctique (Ouest et Extrême Nord). L'Est a connu trois périodes d'anomalie positive : dans les années 1950, aux alentours de 1980 et à la fin des années 1990. Le maximum absolu a eu lieu en 1981. Dans ce secteur, il y a deux anomalies négatives: dans les années 1970 (minimum absolu en 1972) et dans les années 1990 (1992-93). Si on compare les moyennes de deux périodes climatologiques 1941-1970 et 1971-2000, cette partie du Nord a la deuxième période plus froide que la première (moyenne des ΔT = -0,7ºC). Dans le centre, le dernier maximum est plus prononcé (2-3ºC plus haut que les valeurs normales) et tombe en 1998. Ensuite les températures descendent près des valeurs normales. La deuxième période climatique (1971-2000) a la température moyenne légèrement plus basse (moyenne des ΔT = -0,1ºC). L'Ouest se caractérise par un fort réchauffement (env. 4ºC) avec le maximum en 1995 (Alert) ou en 1998 (Sachs Harbour) suivi d'un très brusque refroidissement. La deuxième période climatique est plus chaud que la première (moyenne des ΔT = 0.5ºC). Conclusion : il n'y a pas de tendance homogène dans les changements de la température au Grand Nord; l'Ouest a une tendance positive, l'Est négative.

4-B-4.5

Perception of winter in Canada: a comparaison between Edmonton (Alberta) and Montréal (Québec)

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Canada, the second largest country in the world, is known namely for its large amount of snowfall, as well as the roughness of its cold winters. From coast to coast, more than 100 cm of snow (close to 1000 cm in certain areas of the Canadian Rockies) is expected to fall every winter and even some southern parts of the country see winter stretching over four months. Such a scenario raises the question of how Canadians really feel about winter, snow and cold; these matters are precisely what this paper examines. Although physical aspects of winter have been studied at length, very little has been done in the field of social climatology, particularly in Canada. In order to verify two major hypotheses (do age, and local winter climate influence how Canadians feel towards

winter?), overall 300 residents (just about half of this total in Edmonton, Alberta and in Montréal, Québec) were interviewed about their perception of winter. This study reveals that there is indeed an urban perception of winter (rather quite negative) that is, to a degree, a function of age (winter is perceived to be worse as people get older) and minor differences in the local winter climates.

P1

Caractéristiques bio-optiques du Saint-Laurent marin

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Un projet CRSNG-Stratégique examine les caractéristiques bio-optiques du phytoplancton et du bactérioplancton dans le golfe et l'estuaire maritime du Saint-Laurent (eaux de type 1 et 2 selon la classification optique), en vue d'aider à l'interprétation de la variabilité spatio-temporelle des paramètres optiques détectés par satellite (ou par monitorage in situ au moyen de bouées optiques). Cette affiche présente les buts principaux du projet, ainsi que certains résultats obtenus jusqu'à date. Les variables visées incluent les caractéristiques pigmentaires, les spectres d'absorption phytoplanctonique et l'indice de réfraction, auxquelles sont associées les abondances et la taille des différents groupes de cellules. Ces informations seront ultérieurement reliées aux paramètres optiques inhérents et apparents (absorption totale, atténuation et rétro-dispersion) mesurés in situ pendant les mêmes campagnes.

P2

Phytoplankton response to increased UV-B radiation is influenced by nutrient stress – a comparative study between planktonic communities from two different latitudes (Rimouski, Canada, and Ubatuba, Brasil)

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Phytoplankton is generally harmed by exposure to UV radiation. Hence the ozone-related UV-B (280-320 nm) increase is expected to cause negative effects on the lower levels of the marine food web. However, assessing this is complex, because the phytoplankton response to increased UV-B is quite variable, in part due to different UV tolerance and photo-protection mechanisms. Nutrient stress seems to contribute to this variability: nitrate-limited cells show much increased UV sensitivity in some studies, but not in others. To test this, natural seawater samples were incubated for one day at sea surface in UV-transparent plastic bags, with or without addition of nitrate. This was repeated at the beginning, in the middle and at the end of a phytoplankton bloom, hence providing different nutrient stress start-up conditions. The response is compared between a north-temperate mesotrophic site (Rimouski, Canada) and a tropical oligotrophic site (Ubatuba, Brasil). Results show that adding nitrate has no effect on the UV response unless cells are nutrient-stressed (post-bloom period), indicating a stronger UV effect in nutrient-stressed cells. This response was more clearly seen in the temperate site, the tropical site showing great UV tolerance.

P3

Some significant changes in Beringia Ecosystem.

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Commander Islands one the most unique area in the World in many aspects: geographic location (between Aleutian chain of Islands and Kamchatka peninsula), historical reasons

(II expedition of Vitus Bering, extremely important point for discovery of Alaska and Aleutian Islands), ethnographic reason (only an area for Russia, where a small population of Aleutian people where inhabited from the last century) and a huge variants of biodiversity of mammals, invertebrates, plants - both on the land and underwater on the Ocean. As you may be aware, the number of sea otters has dramatically declined during the last seven years in some parts of the Northern Pacific. At this time, we can foresee a really catastrophical reduction in the population of sea otters near the Aleutian Islands. They seem to disappear for unknown reasons. The same situation is occurring with Steller Sea Lions and some other species which are in the top level of the feeding chain. But most dangerous signal we had in 2000 when on the Commander Islands fond on the beach five dead whales: On the Medniy Island - 3 - all Right Whale On the Bering Islands - 2 - (1 - Right whale; 1- Cuvier's Beaked Whale) In 2001, again on the Bering Island was fond 1 dead Right whale. All these facts clearly display that something is drastically wrong with the natural functions in the whole ecosystem of the Bering Sea. My colleagues and I have been doing intensive research work in the Commander Islands for more than 20 years. From that experience, I can establish beyond doubt that for many natural, historical, economic and other reasons the Commander Islands is an essential focal point for field expedition work and finally for conservation projects in the unique ecosystem of the North Pacific. Evidence gathered and projects originating there will be of vital importance for all countries: the USA, Russia, Canada, Japan, Korea and many others.

P4

Influence of environmental factors on the spatio-temporal distribution of pico- and nanophytoplankton in the St. Lawrence (Estuary and Gulf)

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Living organisms in the marine environment are neither uniformly nor randomly distributed. They are rather agglomerated in patches or distributed according to a gradient or other kinds of spatial structures. The distribution of phytoplankton can be directly related to various environmental factors, such as nutrients, light, temperature or salinity. In the St. Lawrence (Estuary and Gulf), a very dynamic system, the species composition and size structure of phytoplankton, in particular the pico- (0.2-2 µm) and nanophytoplankton (2-20 µm) are poorly described. The environmental factors that trigger changes in both the species composition and size structure of phytoplankon, have not been identified. The purpose of the present investigation is, therefore, to provide some basic data on the spatial and temporal distribution of phytoplankton in the Estuary and Gulf St. Lawrence and their relation to physical and chemical factors. This study was conducted between 17 and 31 May 2000 (late spring) during the SeaWiFs 2000 Cruise. Water sampling (3 depths for each station) was carried out at 44 stations. Results show that the pico and nanophytoplankton abundance as the total phytoplanktonic biomass (Chl a concentration) follow the salinity gradient in the St. Lawrence Estuary. However, in the Gulf of St. Lawrence (oceanic zone), only the distribution of the pico- and nanophytoplankton seems to be directly linked to salinity. This suggest that pico- and nanophytoplanktonic cells can act as tracers of water masses of oceanic origin during late spring.

P5

The return of the diatom *Neodenticula seminae* in the Atlantic: a sign of changes in the Arctic Ocean?

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Neodenticula seminae (Simonsen and Kanaya) Akiba and Yanagisawa is an important member of the modern diatom assemblage in the Bering Sea and at middle and high latitudes of the North Pacific. In the Atlantic Ocean, this species has only been recorded in middle to high latitude Quaternary sediments between 0.84 and 1.26 Ma. The occurrence of *N. seminae* in the North Atlantic has principally been attributed to the presence of low salinity surface waters in the Atlantic during the early Quaternary. Here, we report for the first time since its total extinction in the Atlantic, an intense spring bloom of *N. seminae* in the Atlantic coastal waters. This bloom was observed in late April 2001 and covered most areas of the Gulf of St. Lawrence with concentrations up to 1.5×10^6 cells per liter. Taxonomic identification was confirmed by several experts. Because this unusual spring bloom coincided with a massive intrusion of Labrador Slope Waters into the Gulf of St. Lawrence, we suppose that this Pacific species was introduced naturally into the Gulf (across the Arctic and down the Labrador current), rather than via ballast waters. The return of *N. seminae* on the Atlantic coast is consistent with recent observations indicating a greater influx of Pacific waters into the Atlantic and changes in the circulation and oceanographic conditions in the Arctic Ocean.

P6

Application of a Wind Gust Parametrisation in a Regional Climate Model.

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During the last two decade or so, Western Europe has experienced two major wind storm systems produced by strong cyclogenesis in the North Atlantic Ocean and a major South Foehn event that produced strong mean winds which, when combined with violent gusts, severely affected many countries. Based on a recent "off-line" method proposed by Brasseur (2001) to compute wind gusts, it seems reasonable to implement a similar parameterisation in a numerical model to simulate wind gusts "on-line", i.e., during the course of a simulation. The method, which is physically-based, assumes that gusts occurring at the surface result from the deflection of air parcels flowing higher in the boundary layer. The trigger mechanism for the deflection is attributed to turbulent eddies. To illustrate the performances of this novel method, three severe windstorms are simulated with the Canadian regional climate model using the gust parameterisation at 20-, 5-, and 1-km resolution. The first case is the windstorm VIVIAN which affected Western Europe on February 26-27, 1990, and the second is LOTHAR which hit Western Europe on December 25-26, 1999, and the third, a South Foehn affected the Swiss plateau during November 7-9, 1982. A preliminary analysis shows that the results are highly resolution dependent; when compared with observations, the simulated gusts are becoming generally more realistic with increasing resolution. It is also noticed that the model responses are dependent on the types of lower boundary conditions which affects the stability of the boundary layer, which also modulate the mean anemometer-level

winds which serve as a lower bound of the gust speed. Wind gusts have the potential to generate considerable damage to human infrastructure as well as to forest resources. The gusty nature of the wind during wind-storms can thus have significant economic consequences so it appears worthwhile to provide a tool to help simulate these events.

P7

Climate and Circulation Variability over the Eastern Europe for the Last Decades of XX Century

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The purpose of this research was to analyse the air surface temperature trends on stations of Eastern Europe and mainly Ukraine and to control the corresponding tropospheric circulation changes, with the check of conclusions on air surface trends variability made early. Multi-years data on 12 meteorological stations of Ukraine were used as well as charts of anomalies of atmospheric pressure as well daily synoptic charts for the period 1980-2000. In 1960s the conclusion about nearly-centennial cycle in annually averaged air temperature oscillation was made, by the data of majority of meteorological stations of the Northern Hemisphere including, Arctic regions. The maximum was observed in 1930s and early 1940s and the following minimum was predicted for 1990s. Actually, however, the minimum of hemispheric temperatures were observed in 1950s and the following growth was registered on Ukraine from 1980s. The change of circulation type was recognized to be as a main factor in the annually averaged temperatures oscillation. In 1950s the clearly meridional type was predominant with large amplitudes of synoptic waves that carried sharp weather changes to Eastern Europe, cold spells in winter and spring and droughts in summer. The temperature growth been started from 1980s coincided with another change of general circulation in the Northern hemisphere troposphere. The main feature was the northward expansion of the wedge of the continental subtropic maximum that provided warmer and drier weather on Ukraine in summer and fall and sometimes in winter. Mean temperatures of winter significantly raised and caused the main contribution to the annual warming. However, phenomena of droughts were rare in contrary to 1950s because spring seasons in 1990s were characterized by significant precipitation that further have led to favorable conditions for cereal crops growth and its rich output in the last 5 years (except 1999) on Ukraine. Deficiency of precipitation was registered for fall months and entirely for the last years (30-60% of multi-years average). Besides, another high pressure area became predominant for the recent years over Western Siberia. This like-blocking anticyclone deflects the trajectories of cyclones' north off the Eastern Europe but can cause stationary development of cyclones over central Russia or Ukraine. As an important conclusion the variability in the structure of surface pressure fields connected with some change in the structure of permanent centers of action in the Northern Hemisphere to the end of XX century can be noticed that was not observed in 1950s. This factor obviously provided the warming over Ukraine and Eastern Europe through the last decade.

P8

Evaluating data interpolation in moving sparse noisy data to a uniform grid

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As a step towards validating the Canadian Regional Climate Model, a gridded set of observed data needs to be constructed for comparison. The performance of a data interpolation scheme is examined. The ability of ANUSPLIN, a multi-variate, noisy-data interpolator developed at the Australian National University, to reproduce gridded output from noisy data subsets, was examined by first creating data subsets, adding noise to these subsets, then interpolating from them onto the original grid. In the presence of moderate levels of noise (5-10% of field range), and for coarse (10-25% of global set) data subsets, model data recovery is adequate. Furthermore, ANUSPLIN was seen to perform better in regions of weak gradients (away from shore lines), though in areas where data was more isotropic (interior to the domain), the effect of strong gradients was minimal. In an additional experiment, model data was selected to resemble the real observational network (as contained in the Canadian meteorological archive). Interpolation from this set, yielded results that were good on land and near stations. Further interpolation from an augmented set containing extra stations in the North of Quebec (coincident with stations in the Centre d'Études Nordiques), highlight the need for a stronger observational presence in the North.

P9

On a Front formed at the confluence of Arctic- and Atlantic-derived waters in northern Baffin Bay

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In the southern portion (~75°N) of the North Water region, in northern Baffin Bay, a sharp temperature front between 200 and 400m depth, identified in 1998 and 1999, roughly aligns with the 500m isobath. Here, waters derived from a northern-moving branch of the West Greenland Current (termed 'southern assembly' waters, SA) separate waters with a halocline nearly 2°C colder distinct to the central North Water region (termed "North Water assembly", NWA). The front is manifest by convergence of these two water mass assemblies associated with the cyclonic redirection of SA waters as they approach the shoaling topography of northern Baffin Bay. The structure of SA waters consists of two distinct temperature layers: a cold halocline (S<33.5 PSU; depth < 100 m) and an underlying warm halocline (S > 33.5; Depth >100m) characterized by the presence of water of North Atlantic origin with potential temperature as high as 2.6°C. Profiles of temperature and salinity, as well as time series data indicate active thermohaline interleaving at the frontal interface which support mixing via both double-diffusion and cabelling. Understanding the role of such mixing in determining the structure of waters exported from the North Water region to the central portion of Baffin Bay, and particularly in influencing the water column structure of the Baffin Current, warrants further investigation of the extent and dynamics of the frontal interface south of 75°N.

P10

Examination of Ice Ridging Using Discrete Particle SAR Model

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Snow-covered sea ice is an important component of high-latitude environments. In mapping sea-ice characteristics for ship navigation and climate modeling, one of the key tasks is to estimate ridging intensity. Using a discrete particle model, we examine the occurrence of ridge returns that would be interpreted as such. Our simulation shows that the probability that the return signal from a ridge be identified as a ridge-return decreases with increasing block size. We then present an image processing technique that associates a ridge resolution index and block's thickness which in turn, considering that block size and ridge height are highly related, could be used to get informations about ridge distribution versus height.

P11

The future of Arctic ice: a model's forecast

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With the intent to provide a forecast of ice cover for the Arctic, especially for application of Canadian interests, a regional ice-ocean coupled model is integrated from 1950 to 2050. In addition to the Arctic Ocean, the domain includes northern North Atlantic, Labrador Sea and Hudson Bay and has a horizontal resolution of 50 km. Atmospheric forcing is a combination of data from the National Centers for Environmental Prediction (NCEP) and model output from the Canadian Centre for Climate Modelling and Analysis (CCCMA). Anomalies from the CCCMA model for 1950-2050 are added to the climatological 1950-2000 mean from NCEP. Preliminary results show significant sensitivities to forcing and parameterizations. Results will include validation of the model for 1950-2000, and a forecast of the ice cover for 2000-2050.

P12

Seasonality of biogenic fluxes and production of planktonic foraminifera in response of oceanographic variability in the Northwestern Pacific: Time-series sediment trap observation

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Time-series sediment trap experiments were conducted at several stations (WCT-1 to WCT-8) in the sub-tropical, sub-arctic and Kuroshio Extension oceanographic zones in the northwestern Pacific illustrate seasonal, latitudinal and depth variations in total particulate, biogenic and planktonic foraminiferal fluxes. At each station, two to three trap systems were set at different water depth intervals to evaluate changes of particles during sinking processes. The chemical component fluxes (calcium carbonate, opal and organic matter), total foraminiferal fluxes in terms of weight, and foraminiferal species flux in terms of number of specimens have been analyzed. The sub-tropical stations are characterized by a small total mass flux with calcium carbonate-dominated and opal-depleted compositions of the settling particles. On the other hand, sub-arctic stations are characterized by a large total mass flux, dominated by biogenic opal, and comparatively less calcium carbonate and organic matter. The overall productivity of the biogenic fluxes shows a larger value in the sub-arctic region than that in sub-tropical region. The foraminifer carbonate that reaches the seafloor accounts for an average 20–27% and 22–23% of the total calcium carbonate in the subtropical and sub-arctic region, respectively. Seasonal variations of biogenic components and total foraminiferal fluxes are observed at all stations. Sub-tropical sites showed higher fluxes of total foraminifera

in mid to late June with an assemblage dominated with G. ruber, G. sacculifer and G. glutinata. Stations at sub-arctic are characterized by strong seasonality of foraminiferal fluxes with a very high productivity of G. quinqueloba, N. pachyderma and N. dutertrei during summer. In the Kuroshio Extension foraminiferal fluxes are dominated by N. pachyderma, N. dutertrei and G. bulloides in September-October and June-July. Planktonic foraminiferal fluxes and species turnover are related to seasonal and interannual changes in surface water dynamics coastal upwelling and eddy advection over the continental margins. Seasonal distribution of foraminiferal species fluxes as well as other biogenic particulate fluxes will be discussed in terms of ocean parameters for paleoceanographic interpretation. Dissolution effects on smaller foraminiferal shell fraction showed strong sign of lateral advection during sinking process, implicated by the differences of compositions and assemblages between tarps in different depths at specific sites.

P13

Estimation of biogenic carbon export from the surface waters of the North Water (northern Baffin Bay) at the end of the phytoplankton growth season

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Biogenic carbon export from surface waters to the deep ocean was estimated in the North Water (NOW) from late summer (27 August) to early autumn (1 October) 1999 using different approaches. In a steady-state system, the potential export of biogenic carbon from the upper ocean would be stoichiometrically equivalent to phytoplankton new production. During the late summer-early autumn period, the average new production, based on nitrate-15 uptake by phytoplankton during incubations and the sestonic C/N ratio, was 340 mg C m ^ -2 d ^ -1. This value is consistent with new production of 317 mg C m ^ -2 d ^ -1 estimated from the nitrate removal in the euphotic zone. However, over the same period, the average new production estimated the traditional way, by multiplying total particulate primary production times *f*-ratio (i.e. the ratio between nitrate uptake and total nitrogen uptake), was 161 mg C m ^ -2 d ^ -1. This estimate compares well with the organic carbon fluxes determined at 100 m-depth with short-term free-drifting particule interceptor traps (177 mg C m ^ -2 d ^ -1) and the patterns of thorium-234/uranium-238 disequilibrium (104 mg C m ^ -2 d ^ -1). These results permit to define two types of new production: 1) particulate new production, i.e. the fraction of total primary production which leaves the surface layer only as particulate carbon, calculated from the *f*-ratio and 2) total new production, which combines export of particulate as well as dissolved carbon, obtained directly from phytoplankton nitrate-15 uptake rates. The study suggests that the vertical transport of dissolved organic carbon may represent about half of the total (particulate plus dissolved) biogenic carbon exported from the euphotic layer of the NOW at the end the phytoplankton growth season. During this period, total new production (12 g C m ^ -2) was relatively low compared to the annual total new production of 147 g C m ^ -2.

P14

Responses of the picophytoplanktonic community to ultraviolet radiation in the High Arctic

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Recently, the Arctic has experienced a recurrent springtime thinning of the stratospheric ozone layer resulting in increasing ultraviolet-B radiation (UVBR; 280-320 nm). However, little is known about the effects of such UVBR enhancement on marine Arctic planktonic communities. The goal of the present study was therefore to assess the short-term effects of UVBR on surface waters picophytoplanktonic communities (0.2 to 2 microns) in the North Water Polynya (NOW, 75-79º N), during fall 1999. Incubations of natural planktonic communities were performed during 12/12 h day/night cycles, at 11 stations from September 18th to October 1st. Water samples were submitted to a constant artificial photosynthetically available radiation (PAR, 400-700 nm) with or without artificial gradient of ultraviolet radiation (UVR, 280-400 nm) during 8 to 12 hours, then placed 12 hours in the dark for dark repair processes to occur. We report here the results gathered for 3 stations along the Greenland coasts where picophytoplanktonic concentrations were relatively high. The enhanced UVBR seems to induce a delay in the algal cell cycle which prevents cell division and caused a cell enlargement. This led to a decrease in picophytoplankton concentration after 24 hours. Our results suggest that the Arctic picoplankton is sensitive to increasing UVBR doses through DNA damages that affect the cell division.

P15

McGill Paleoclimate Model Ice Sheet Sensitivity to Ice Flow Rate and Discharge Parameters

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Sensitivity studies of the ice sheet model and forcing in the McGill Paleoclimate Model (MPM) are presented. The MPM is a five component (atmosphere, ocean, sea ice, land surface, ice sheet) sectorially averaged Earth system Model of Intermediate Complexity (EMIC). An isothermal flow line model is employed for the ice sheet component, where the flow is considered to be exclusively in the meridional (north-south) direction. The formulation for the lateral (east-west) flux of ice into the ocean is that of Gallee et. al. (1992). In this scheme the lateral length scale of the ice sheets is parameterized by assuming the ice sheets to have a perfect plastic behaviour in the east-west direction. The meridional flow of ice in the ice sheet component depends on the temperature dependent flow parameter, or rate factor. A sensitivity study is performed on this parameter. The ice flow rate factor is found to have a large effect on both the ice volume and the extent of the southern margin. Values corresponding to equivalent temperatures of -7C and -4C are most appropriate for the initiation of glaciation (formation of Laurentide and Fennoscandian ice sheets) during the last glacial period. The formulation for the lateral ice discharge is improved to allow for a more realistic description of the east-west length scale of the ice sheets. Significant increases in both the ice volume and growth rate are obtained. To improve the ice sheet-atmosphere coupling in the MPM, a high resolution nested land surface component is introduced. By calculating the land surface processes on the higher resolution of the ice sheet component, a more accurate representation of the dependence of the surface air temperature on the surface elevation of the ice sheet can be included. This removes grid related artefacts from the equilibrium ice sheets determined by the model. It is shown that this high resolution nested

component does not significantly affect the growth rate of the ice sheets during the initiation phase of glaciation.

P16

The Mackenzie GEWEX Study Data Archive: a Dataset for Climate modelling

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The Mackenzie GEWEX Study (MAGS) is aimed at improving our understanding and prediction of the role of water and energy cycles in the climatic system in the Mackenzie River basin. The goals of the MAGS Data Management system are to establish, maintain, describe, and promote accessibility and distribution of the data sets necessary to meet the MAGS objectives in the data sparse Mackenzie River basin. These goals are being met by MAGS in a number of ways: through the availability of data and information through the World-Wide Web; through the production of specialized data products; and through the development of policies to govern data exchange and participant interactions.

The MAGS web site is the primary method of providing information on the activities and data collected in the project for its many participants in universities and government offices across Canada as well as for the outside world. Visitors to the site have access to over 300 pages of information describing the objectives,

background, status, and clients for the project. In addition, nearly 1 Gb of data collected in the study area is available through the site.

Additional data is available to MAGS participants through the "Participant's Only" section. Selected data sets are available there in near real time. These include GOES (4 channels) and AVHRR (IR and visible) satellite imagery and enhanced observations from the MAGS surface sites and buoys. The GOES imagery is received every 12 hours and the AVHRR data is received within 30 minutes of capture. The enhanced data sets from the surface sites are transmitted daily and contain enhanced temporal resolution data (for example, 15 minute pressure measurements) and non-standard measurements (such as soil temperatures).

Special CD-ROM archives of the datasets collected during a specific case studies and about scientifically interesting processes within the basin are also being produced by MAGS. These archives will provide a lasting resource for future climate change studies.

This poster will describe the contents, structure and utility of the MAGS Data Archive in conducting climate research.

P17

Étude de la sensibilité des modèles couplés MRCC-MOG sur un cycle annuel pour la région du Golfe du Saint-Laurent

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Afin d'améliorer la compréhension du climat et de sa variabilité, il est nécessaire de considérer le système climatique dans son ensemble, plutôt que chacune de ses composantes individuellement. Les interactions entre l'atmosphère, l'océan et la glace marine font partie des processus importants régissant le climat de l'est du Canada, du fait de la proximité de l'Océan Atlantique et de trois grands bassins d'eaux, les Grands Lacs, le Golfe du Saint-Laurent et la Baie d'Hudson. Le laboratoire de modélisation régionale du climat de l'UQAM et l'Institut Maurice Lamontagne ont entrepris l'élaboration d'un système couplé atmosphère-océan-glace pour les eaux côtières de l'est du Canada, incluant le Golfe du Saint-Laurent et la Baie d'Hudson, afin de parvenir à une meilleure compréhension et représentation du climat de l'est du Canada. Faucher (2001) a effectué une étude de sensibilité des modèles, le Modèle Régional Canadien du Climat (MRCC) et le Modèle Océanique du Golfe du Saint-Laurent (MOG), durant la saison hivernale de 1989-1990 pour la région du Golfe du Saint-Laurent. Le projet proposé consiste à poursuivre la validation du système couplé sur un cycle annuel. La réaction des modèles peut être différente durant l'été, où la circulation atmosphérique est généralement plus faible. De plus, il est possible que certains effets du couplage se révèlent sur une plus longue période de temps du fait de la grande inertie du milieu océanique. Pour ce faire, les deux modèles sont utilisés indépendamment et en alternance pour chaque simulation sur la période d'étude. Les champs utilisés comme champs de forçage de surface atmosphériques ou océaniques sont simulés et échangés entre le MRCC et le MOG. Cette expérience nécessite la réalisation de plusieurs itérations afin de pouvoir étudier l'évolution des solutions de chaque modèle. Les premiers résultats de cette étude seront donc présentés.

Faucher, M., 2002: Sensibilité du climat dans la région du Golfe du Saint-Laurent a l'interaction de simulateurs régionaux atmosphérique (MRCC) et océanique (MOG). Thèse de Doctorat, Université du Québec A Montreal. Déposée en janvier 2002.

P18

Incorporation du routage des rivières dans le modèle régional canadien du climat (MRCC)

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Le récent couplage entre les modèles atmosphériques et océaniques nécessite la connaissance de nouvelles variables. L'une d'entre elles est la quantité d'eau douce qui afflue à l'océan via les rivières. Cette quantité d'eau douce peut être calculée dans un modèle climatique en implantant un schéma de routage de rivières qui consiste à simuler le ruissellement de l'eau sur la terre jusqu'à l'océan. La quantité d'eau douce est nécessaire au modèle océanique, car elle constitue un des principaux forçages sur l'océan. Sa densité étant plus faible que celle de l'eau salée, elle affecte directement la formation de la glace, ainsi que la circulation thermohaline. En fermant le cycle hydrologique, le routage peut servir à calculer le débit d'eau douce à l'embouchure des principales rivières considérées. Les débits simulés pourront alors être comparés aux débits réels mesurés, afin de valider l'hydrologie du modèle climatique. Aussi, une fois le routage bien implanté dans le modèle climatique, nous pourrons étudier l'impact des changements climatiques sur le cycle hydrologique. Ces raisons ont motivé l'implantation du routage de rivières dans le modèle régional canadien du climat (MRCC). L'algorithme de routage retenu est celui d'Arora et Boer (1999). Cet algorithme à vitesse variable considère deux réservoirs, l'un souterrain et l'autre en surface. Pour modéliser le parcours de l'eau, ce routage estime une coupe transversale rectangulaire de la rivière selon une largeur fixe et une hauteur qui varie selon plusieurs paramètres. Le domaine du MRCC couvre la majeure partie de l'Amérique du Nord. Afin d'implanter le routage dans le MRCC, une interpolation sera nécessaire afin d'identifier, pour chaque cellule de la grille du MRCC, la direction de l'écoulement ainsi que les bassins versants considérés. Plusieurs autres paramètres, tels la pente du lit de la rivière et le type de sol, contrôlant le ruissellement de l'eau doivent également être déterminés.

Arora, V.K., and Boer, G.J. (1999) A variable velocity flow routing algorithm for GCMs, J. Geophy. Res., 104 (D24), 30965-30979

P19

Modélisation mathématique pour certains problèmes d'environnement mathématiques et informatiques

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La théorie des équations aux dérivées partielles engendre plusieurs classes de phénomènes physiques, notamment, la glaciologie, phénomène de réaction diffusion, interaction terrestre, fluides non Newtoniens. Ce dernier étant en liaison directe avec l'environnement.

Dans ce travail, on présente une équation Mathématique qui modélise des problèmes physiques. On essaie de trouver les solutions admissibles de cette équation, en étudiant la fonctionnelle énergie correspondante, par des méthodes de minimisation très connues dans le domaine des EDP. Plus précisément, on étudie un problème elliptique non linéaire où le fameux opérateur p-Laplacien intervient. Ensuite on s'intéresse à la régularité de ces solutions pour bien les localiser.

Notons enfin, que pour des cas particuliers pour le paramètre p, on retrouve le cas concret des problèmes liés à l'environnement.

P20

Energetic conditions of the atmosphere in Atlantic-Europe region during natural synoptic periods (NSP)

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The research of energetic conditions of the atmosphere in Atlantic-Europe region during natural synoptic periods (NSP) is presented. The diagnosis focuses on such characteristics as the kinetic energy content (K), horizontal flux divergence of K (FK), generation by cross-contour flow (GK). As original data were taken the 1000 to 300 mb grid fields on mandatory levels derived from MetOffices' objective high resolution analysis. The energetic calculations were carried out on domain extending from 20 degree W to 60 degree E and 40 to 70 degree N, on whole domain and separate sectors. The analysis is showed that during NSP oscillations of values K, FK, GK depend on a type of dominant large-scale processes in the region as cyclogenesis or antycyclogenesis. The flux and increase of kinetic energy content in time is possible to identify with processes of anticylogenesis, and reduction of K correspond to predominant of cyclogenesis in calculated domain. The main horizontal flux divergence (FK>0) is occurred in front parts of the upper-level troughs and ridges in active supergradient frontal zone. The generation of kinetic energy (GK>0) is observed in the widespread anticyclones and in front parts of upper-level ridges. The areas of maximum and minimum rates of K, FK, GK are formed from first to second day of NSP and localized during this time with changing of its intensity. These properties of integrated values of energetic characteristics may be use as indexes for determination of type of NSP and its temporary limits.

P21

Development of gridded snow water equivalent data for GCM validation using the CMC snow depth analysis scheme

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Validation of GCM snow cover has been hampered by a lack of reliable gridded estimates of snow water equivalent at continental scales. To address this gap, the CMC snow depth analysis scheme was used in reanalysis mode to generate a 0.3 degree lat./long. grid of monthly mean snow depth and water equivalent for North America for validating GCM snow cover simulations for the AMIP II (Atmospheric Model Intercomparison Project) period (1979-1996). Approximately 8000 snow depth observations/day were obtained from US cooperative stations and Canadian climate stations for input to the analysis. The first-guess field used a simple snow accumulation, aging and melt model driven by 6-hourly values of air temperature and precipitation from the European Centre for Medium-range Weather Forecasting (ECMWF) ERA-15 Reanalysis with extensions from the TOGA operational data archive. Extensive validation of the historical analysis with independent in situ and satellite data revealed that the gridded dataset was able to successfully capture the important features of the North American snow cover climate. The snow depth climatology revealed a number of improvements over previous products, namely an improved representation of the snow line in June and October, and a more realistic spatial distribution of snow over the western cordillera. The dataset successfully captured interannual variability in snow cover extent and SWE during the November to April period, but was less successful in the May-October period when the snowline was located over data sparse regions of NA. Overly rapid melt of snow in the spring contributed to this problem at high latitudes.

P22

ELBOW 2001 Radiosonde Analysis

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Effects of Lake Breezes on Weather (ELBOW 2001) was a field project designed to improve our understanding of how lake breezes can interact with one another and with incoming synoptic scale features in Southwestern Ontario. Measurements taken in this project included radiosonde data. Three fixed locations for radiosonde releases were set up; one at Port Franks on Lake Huron, a second at Port Stanley on Lake Erie, and a third at the University of Western Ontario Farm just North of London. A Mobile Jeep was also set up with a fourth radiosonde system. The data from these systems are being processed by a Rawinsonde Observation Program (RAOB 5.0). Radiosonde data collected give us a view of the vertical profiles on both sides of the lake breeze front and in some cases, while the lake breeze was passing through. It is expected that these data will help us to better understand lake breeze structure and why there is significant storm development in certain situations and less in others.

P23

Radar observations of lake breeze induced summer convective storms.

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Observations of convective precipitation made with a portable X-band radar are compared to images retrieved from the Exeter C-band operational radar situated in southern Ontario during Elbow 2001: The Effect of Lake Breezes On Weather. Attempts were made to locate and identify convective precursors of severe weather due to lake breeze boundary interactions with the X-band radar. As a diagnostic and prognostic observation and analysis tool, the X-band was able to make contributions to the research from the perspective of scanning flexibility. In comparison, the more sensitive C-band operational radar performed far better as a means of detecting boundary interactions well in advance of severe weather, making it a more effective research tool. The boundary interactions on June 19, July 19, and July 23 of 2001, are presented as case studies to illustrate the performance strengths of each radar.

P24

Estimating Active Layer Thaw Rates in the Kuparuk River Basin, Alaska, with NOAA AVHRR-Derived Surface Temperature Time Series

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Recent developments in the field of remote sensing, and in particular the availability of long time series of NOAA AVHRR data, have led to an increase in the application of satellite imagery for environmental monitoring. In this paper, we demonstrate the potential of AVHRR 10-day composite brightness temperature time series for monitoring active layer thaw rates in summer. Our primary intent was to examine if the satellite-derived surface temperatures followed the same general temporal trajectories as the air/ground temperature measurements during the course of summer. AVHRR-derived surface temperature values are first compared to mean air temperature and mean near-surface ground temperature measurements from permafrost sites. Accumulated degree-days of thaw (ADDT) are then calculated from the AVHRR surface brightness temperature 10-day composite data set through interpolation between 10-day intervals and summed over the period of interest. Lastly, the AVHRR-derived ADDTs are assimilated into thawing indices calculated from near-surface ground temperature and active layer thaw depths at several sites within the Kuparuk River basin. Results show that the composite summer temperature curves and sums of degree-days derived from AVHRR are adequate matches with the near-surface temperature curves of several sites. The best relationships between satellite-derived ADDT and thaw depth are generally found in areas of low vegetation density and low relief since effects due to the presence of a canopy and/or topography (slope/aspect) are minimised.

P25

Approach to quantitative risk analysis of land use in permafrost areas

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Probability of changes of climate and landscapes in permafrost areas are the subject of increased interest due to the global warming and human impact on the environment. The long-distance transportation of oil and gas expose the environment of permafrost areas to the risk of underground and surface water contamination. Modern activity of dangerous surface processes in the North affects roads, pipelines, and buildings. The Geographic Information Systems (GIS) now enable to gather a variety of information and adopt simulation technologies. Our research project is focused on the studies of permafrost disturbance and includes the use of analysis and interpretation of remotely sensed multispectral imagery. A database collection and advanced distributed simulation

are expected to estimate the risks of pipeline failures and other construction damages in permafrost areas due to geocryological processes. The analysis of satellite imagery and aerial photos is used for digital landscape mapping. In order to calculate major permafrost parameters - temperature of soil and active layer depth - geological and meteorological characteristics of landscapes (air temperature, thermal conductivity of snow, soil, etc.) are considered according to the recently established and approved technique. As the result of the first stage, a digital permafrost map is made for the Central Siberia region. In the second stage, the probabilities of microclimate change and surface disturbance are calculated. Natural fluctuations of meteorological parameters and probability of human impact are estimated for the calculations. Then the probabilities of permafrost disturbance and consequent impact on construction are obtained for various landscape conditions.

P26

Le recul récent du glacier C-79 sur l'île Bylot, archipel arctique canadien

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L'île Bylot est située dans l'Arctique canadien, au nord de l'île de Baffin. De nombreux glaciers prennent naissance dans les montagnes de la Cordillère arctique qui traverse l'île en son centre. Ceux-ci s'écoulent sous forme de grandes langues lobées vers les basses terres en contrebas. La majorité des glaciers sont présentement en régression. En particulier, nous avons documenté le recul du glacier C-79. Au cours de l'été 2001, nous avons cartographié précisément la position actuelle du front glaciaire grâce à une série de mesures au GPS. Son recul par rapport à sa moraine frontale néoglaciaire, ainsi que des taux de recul ont pu être mesurés précisément. De plus, sa position actuelle a été comparée avec celles d'années antérieures, observables sur des photos aériennes (1958 et 1982) et des images satellitaires (1990). De nombreuses formes glaciaires apparaissent au front du glacier : moraine médiane, moraine frontale, moraine à cœur de glace... Plusieurs formes fluvioglaciaires actives témoignent de la fonte du glacier : tunnels, flancs de glace, bédières, lac proglaciaire, chenaux anastamosés. De toute évidence, le front glaciaire couvert de débris morainiques s'est abaissé récemment. Cette analyse indique un recul marqué du glacier C-79 depuis les 50 dernières, et particulièrement au cours des 20 dernières années. Ce retrait semble lié au réchauffement climatique régional. Mots-clés : géographie physique, géomorphologie glaciaire, fluvioglaciaire, recul glaciaire, cartographie, réchauffement climatique

P27

Winter sources of mixing in the Gulf of St. Lawrence

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The fall and winter processes of water mass and sea-ice formation and circulation in the Gulf of St. Lawrence are examined using a three-dimensional coastal ocean model with realistic tidal, atmospheric, hydrologic, and oceanic forcing. The ocean model includes a level 2.5 turbulent kinetic energy model. A model simulation over 1996-97 is verified against available data on sea ice, temperature, and salinity. The results demonstrate consistent atmosphere-ocean exchanges and the known features of the circulation and sea ice cover. The mixed layer deepens to more than 100 m depth as seen both in the data and in the model results. The production of turbulent kinetic energy and the associated vertical mixing are examined as functions of shear (from the winds, tides, and internal waves), surface buoyancy loss from advection and air-sea exchanges, and

turbulent master length scales. Different regions of the Gulf respond very differently because of large regional differences in the ambient stratification, the sea ice cover and topography. The analysis allows us to understand the relative importance of advection, sea ice, tides and the surface heat and momentum exchanges controlling the production of turbulent energy and the formation and erosion of the intermediate and deeper layers found in the Gulf of St. Lawrence.

P28

Système de prévision immédiate pour le stratus à l'aéroport de San Francisco (SFO)

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L'été 2001 fut la première saison de démonstration et d'évaluation d'un système d'analyse et de prévision à courte échéance pour le stratus à SFO. Ce projet a été développé par une équipe interuniversitaire incluant le San Jose State University, l'Université du Québec à Montréal, le Pennsylvania State University et le MIT-Lincoln Laboratory. Le système a été spécifiquement conçu pour SFO où le problème d'engorgement de l'aéroport, et son impact économique, devient important lors de la présence prolongée de stratus dans la zone d'approche puisque alors, une seule piste d'atterrissage sur deux est disponible. Le système fournit une prévision révisée à toutes les heures du moment où l'aéroport pourra recevoir des avions sur ses deux pistes d'atterrissage parallèles. La prévision de stratus est le résultat d'un consensus entre plusieurs modèles dont trois sont statistiques et un est physique (modèle colonne COBEL). Les caractéristiques générales des quatre modèles utilisés pour établir la prévision seront présentées, avec emphase sur le modèle colonne COBEL développé à l'Université du Québec à Montréal. L'évaluation de ce système ainsi que sa planification pour son implémentation à l'été 2002, seront également présentées.

P29

Utilisation de la glace de lac comme indicateur de variabilité et de changements climatiques au nord du Canada

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Des études effectuées en Scandinavie, Russie et États-Unis ont démontré que la glace de lac est un bon indicateur de la variabilité et des changements climatiques. La glace de lac étant une composante importante de la cryosphère, une étude pan-canadienne était de mise pour évaluer les impacts des changements dans le Nord du pays. Dans cette étude, nous avons extrait de la Base de Données Canadienne sur la Glace (BDCG), les données concernant les états (dates de formation et de fonte) de la glace pour différents sites à travers le Canada. La sélection des lacs a été effectuée par l'entremise de requêtes ayant 3 critères principaux, le premier étant la sélection des lacs les plus nordiques. 25 lacs ont donc été retenus afin d'examiner si des tendances significatives existaient dans la durée de l'englacement pour une période de 23 ans (1963-64 à 1987-88). La réalisation de graphiques a permis de dégager des tendances, souvent opposées, dans la durée de l'englacement entre le Nord-Ouest (environ 20 jours de moins sur 23 ans) et le Nord-Est (environ 11 jours de plus sur 23 ans).

P30

Suivi des fluctuations climatiques survenues dans le Bassin du Mackenzie à l'aide de la télédétection en hyperfréquences passives du couvert glaciellacustre.

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Le Bassin du Mackenzie fait partie des régions du monde qui ont connu, au cours des dernières décennies, un important réchauffement climatique. Face à cette constatation, le gouvernement canadien a mis sur pied le projet Mackenzie GEWEX (Global Energy and Water Cycle Experiment) Study (MAGS) visant à comprendre et à modéliser le système climatique du Bassin du Mackenzie. En parallèle, le projet CRYSYS (CRYospheric SYStem to monitor global change) est fondé dans le but de développer des façons d'améliorer la compréhension et la surveillance des composantes de la cryosphère. Parmi ces composantes, on retrouve la glace de lac qui offre un potentiel indéniable à titre d'indice climatique : retrouvée en abondance pendant une grande partie de l'année sur les nombreux lacs du Bassin du Mackenzie, elle fournit, par le biais de ses dates d'englacement et de déglacement, une information disponible à grande échelle et extractible à l'aide d'images satellites. Dans le cadre de cette étude, différents types de données sont combinés dans le but d'effectuer le suivi de l'englacement et du déglacement de quatre lacs du Bassin du Mackenzie : le lac des Esclaves, le lac de l'Ours, le lac Athabasca et le lac Claire. Des données provenant de stations météorologiques situées à proximité des lacs, ainsi que des données in situ d'épaisseur de glace et de neige permettent de valider les images satellites provenant des capteurs en hyperfréquences passives SMMR (19GHz) et SSM/I (19 et 85GHz). Des résultats préliminaires ont démontré qu'il existe un lien étroit entre le comportement du signal de température de brillance à ces fréquences et les caractéristiques du couvert glaciel et du plan d'eau lacustre. Cette relation est analysée dans le but d'en déceler les particularités et dans celui de caractériser le réchauffement du climat de cette région du Nord canadien.

P31

Étude de la Dynamique Spatio-Temporelle Récente des Lacs Thermokarstiques de la Plaine Old Crow, Yukon, par Télédétection

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Les lacs thermokarstiques sont des formes de terrain caractéristiques du pergélisol en dégradation. Les températures annuelles moyennes à Old Crow ont augmenté d'environ 2°C depuis 1969. Ayant observé une chute du niveau des lacs, les résidants de Old Crow craignent que les températures plus chaudes et les printemps plus précoces risquent d'assécher la plaine Old Crow, menaçant ainsi leur mode de vie traditionnel. Cette plaine représente l'une des terres humides les plus importantes du Yukon. L'analyse de photographies aériennes (1944-1976) et d'images Landsat MSS et TM (1973-1999) nous permet de détecter les changements dans la superficie couverte par les lacs. En employant diverses techniques de détection de changements telles que les composés colorés, la différenciation d'images post-classifiées et les ACP, il nous est possible de cartographier la dynamique récente des lacs thermokarstiques de la plaine Old Crow tout en détectant, identifiant et quantifiant les changements survenus. Les

premiers résultats démontrent qu'il y a eu un assèchement d'environ 2,8% de la plaine entre 1973 et 1999. Cette étude permet d'examiner de façon préliminaire l'effet d'un réchauffement climatique sur le pergélisol dans le Yukon nordique et de valider l'hypothèse d'un assèchement récent. Elle permet également de déterminer l'apport de la télédétection dans l'étude des dynamiques spatiale et temporelle des lacs thermokarstiques, et d'en établir les limites.

P32

Sensibilité du couvert de glace de certains lacs du bassin du fleuve Mackenzie aux changements climatiques

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Un modèle de glace lacustre thermodynamique unidimensionnel (Canadian Lake Ice Model ou CLIMo) est présenté et utilisé pour évaluer la réponse de la glace lacustre face à la variabilité du climat et aux changements climatiques. Les simulations ont été réalisées à l'aide des données provenant de la station météorologique de l'aéroport de Yellowknife (T.N.-O.) et couvrent une période de 41 années (1960-2000). Les données nécessaires au fonctionnement du modèle sont : la température de l'air, l'humidité relative, la vitesse du vent, la couverture nuageuse et la neige au sol. De plus, la densité de la neige calculée à partir des mesures d'équivalent en eau de la neige est utilisée lorsque disponible. Les données d'entrée ont été modifiées suivant les prévisions du modèle de circulation global canadien en fonction d'un scénario de doublement de la quantité de CO2 dans l'atmosphère. Le modèle génère plusieurs informations, notamment l'épaisseur de glace et de neige, ainsi que les dates de formation et de disparition du couvert glaciel. Les résultats démontrent la grande sensibilité de la durée d'englacement des lacs face à une augmentation des températures de l'air. Par ailleurs, les précipitations solides jouent un rôle déterminant dans l'évolution d'un couvert de glace lacustre. Ainsi, un changement de la quantité et/ou de la distribution dans le temps des chutes de neige affecte grandement l'épaisseur du couvert glaciel.

P33

Determination of integrated water vapour using a GPS receiver: Results from the MAGS project

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Although a relatively new science, the measurement of atmospheric water vapour using Global Positioning System (GPS) receivers has been demonstrated to give results comparable to more conventional forms of water vapour measurement. This study involves data collected from two GPS receivers as part of the Mackenzie GEWEX Study (MAGS), one located north of the University of Waterloo in Waterloo, Ontario and the other temporarily located at Ft. Smith, NWT and then re-located to northern Saskatchewan. This study is a continuation of a project started in 1999, results have now been completed for 2001. The method is based on the observation that the radio signals between GPS satellites and GPS receivers are delayed as a result of passing through the

atmosphere. This delay is caused by the dipole moment of water molecules that impedes the propagation of electromagnetic radiation through the atmosphere. The effects of the ionosphere can be removed using characteristics of the GPS signal, and the residual delay can be split into the hydrostatic delay and the wet delay. The hydrostatic delay can be independently calculated using surface pressure measurements. The integrated water vapour can then be related to the wet delay using a proportionality constant. This constant varies depending on atmospheric conditions with the most significant factors related to the mean temperature of the atmosphere and the surface pressure. The GPS receivers used in this study are located near surface meteorological stations allowing accurate measurement of surface meteorological parameters to be used in the calculation of integrated water vapour. This study presents comparisons of integrated water vapour calculated from the GPS receivers and various other sources including: profiles produced by the corresponding CMC GEM model runs and direct upper-air measurements from the closest measurement locations.

P34

The Influence of Ionic Strength and Fluoride Ion Concentration on the Adsorption Properties of Gibbsite: Phosphate and Arsenate Adsorption

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Anomalously high concentrations of arsenic and phosphate are found in the sediments of the Saguenay Fjord relative to those of the Gulf and St. Lawrence Estuary. Whereas the source of phosphate is likely anthropogenic, arsenic appears to be scavenged from the bottom marine waters. The adsorption of phosphate and arsenic to various mineral oxides is well established but the precise scavenging agent(s) in this particular environment is not known. The surface waters of the Saguenay Fjord show a particulate aluminum anomaly that decreases downstream or with increasing salinity. The aluminum is introduced as a result of the activities of the aluminum refining facilities and harbor activities upstream. The most likely solids introduced to the waters from these activities are bauxite, the ore mineral, and gibbsite Al(OH)3, an intermediate product of the refining process. A recent study carried out in our laboratories revealed that the adsorption capacity of gibbsite for phosphate and arsenate is decreased significantly in seawater relative to freshwater. These observations imply that trace elements adsorbed onto aluminum oxides in fresh waters will desorb and be released to the solution upon mixing with marine waters. We propose that fluoride (F-), a major, conservative constituent of seawater (> 1ppm), either competes with other anions (e.g., HAsO4-2, HPO4-2) for the OH+ (pHPZC for gibbsite " 9.5) surface sites or substitutes for the hydroxyl on the surface of gibbsite. On the basis of this working hypothesis, we measured the adsorption capacity of gibbsite for arsenate and phosphate in pure water; 0.7m NaCl; 10 mM CaCl2; 10 mM CaCl2 + 0.64 M NaCl and in seawater in the absence and presence of the fluoride ion. In the latter case, the fluoride activity was buffered by the addition of a fluorite (CaF2) crystal to the solution. Results of the adsorption and fluorite equilibration experiments will be presented.

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