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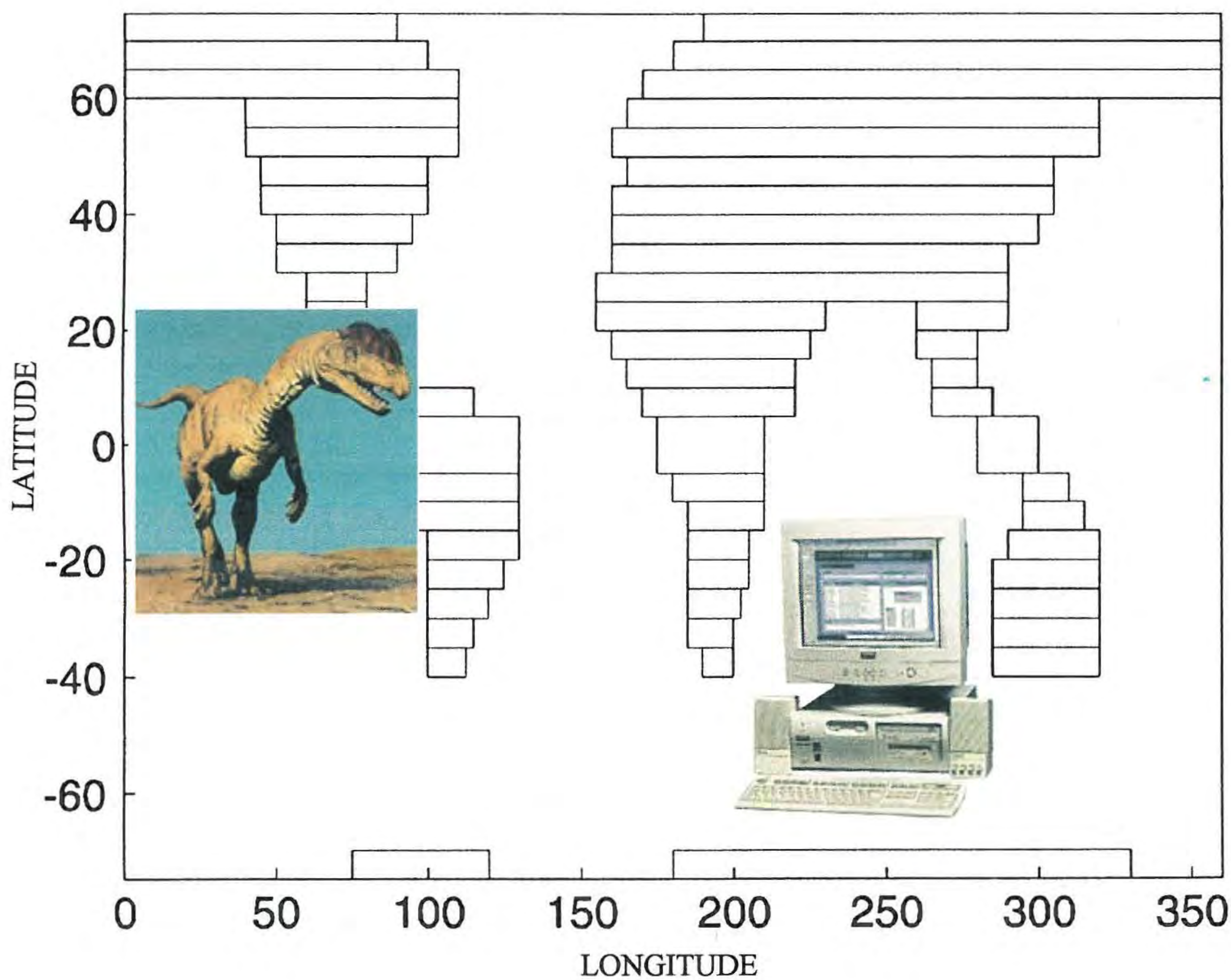

CMOS Bulletin SCMO
"at the service of its members
au service de ses membres"

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Cover page: The McGill Paleoclimate Model (MPM) has been used to investigate the atmosphere-ocean mechanisms that produced a very warm and equable climate at the time, about 100 Ma Before Present. Equable climate means small temperature gradient between the equator and the poles - i.e., warm polar regions, with no sea ice. To learn more, read the article on page 104.

Page couverture: Le Modèle paléoclimatique de McGill (MPM) a été utilisé pour étudier les mécanismes atmosphère/océan qui ont produit un climat très chaud et uniforme à cette époque, il y a environ 100 millions d'années. Le climat uniforme signifie un petit gradient de température entre l'équateur et les pôles, c'est-à-dire des régions polaires chaudes n'incluant aucune glace marine. Pour en savoir plus, lire l'article en page 104.

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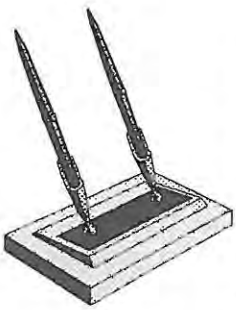
Canadian Meteorological and Oceanographic Society (CMOS)

Société canadienne de météorologie et d'océanographie (SCMO)

....from the President's Desk



June and July used to be quiet, tranquil, holiday months; no classes, not too many deadlines and a chance to catch up on some research, even manage a week or so away! Fortunately I did get a week's holiday added to a conference in Nice in April and I **WILL** get away for the last week of August, but the past two months seem to have been exceptionally busy.

The new CMOS Executive Committee (myself, Ron Stewart, Mike Stacey, Bill Schertzer and Fred Conway) have been learning the ropes, with lots of help from Ian, Neil, Richard and Dorothy in Ottawa. Our first executive meeting in late June lasted, according to Bill Schertzer's 11 pages of minutes, almost six hours, but meeting number 2 in late July was shorter and we will get better! Joking aside, the executive does have a number of issues to deal with and some need careful thought.

June/July also saw a change in the upper management at the Meteorological Service of Canada (MSC) with Gordon McBean's departure and Marc Denis Everell's arrival as the new Assistant Deputy Minister. A highly successful MSC farewell event was held for Gordon in Downsview on June 28th, followed by a lunch in Ottawa on June 29th organised by the Ottawa CMOS Centre and CMOS Executive Office. A highpoint of both events was a performance video produced by a group of Victoria musicians, including Howard Freeland, co-chair of the Scientific Committee for our Victoria Congress and well known video enthusiast. I am not sure if copies are available anywhere but it should go in someone's archives.

J'espère que nous aurons les mêmes bons rapports avec le Dr. Everell et son équipe à SMC dans les années à venir que ceux que nous avons eu avec Gordon McBean dans le passé. Vraiment nous avons les mêmes préoccupations concernant la santé des sciences de l'atmosphère et des océans mais c'est aussi nécessaire que la SCMO représente les avis plus large que ceux du SMC, par exemple, en défendant la cause du secteur privé. Dr Everell et Dr McBean servent tous deux dans le Conseil d'administration de la Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA/CFCAS) et j'attends avec impatience leur participation.

On the topic of the Canadian Foundation for Climate and Atmospheric Sciences it is exciting to report that the Board of Trustees was appointed at the end of July and the first call for letters of intent and proposals was issued in late July - check their new web site, www.cfcas.org, also accessible from www.cmos.ca or www.scmo.ca, for many more details of Foundation activity.

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Inside / En Bref

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Severe weather has certainly been a feature of this summer, as it often is, and the tornado at Pine Lake, Alberta was an especially tragic and dramatic illustration of the damage and destruction that can be caused. Prompted in part by John Reid's and Bill Pugsley's e-mails, and impressed by the Globe and Mail editorial of July 18, I was motivated to write a letter to the Globe. They chose not to publish it but let me extract a couple of thoughts from it here

"Action is needed on two fronts,

> 1) Improved monitoring, mostly with Doppler radar, and research into improving skill in recognising tornadoes and the mesoscale weather patterns likely to spawn them. The Meteorological Service of Canada (formerly the Atmospheric Environment Service) was the first national weather service to use Doppler Radar on an operational basis (King City radar) and, together with radar groups at Canadian universities such as McGill, has the expertise to advance and deploy these technologies.

2) Improved dissemination of weather warnings. The Canadian Meteorological and Oceanographic Society (CMOS) have been pressing the CRTC for urgent action on this for some time, and some action, at least as far as cable TV subscribers are concerned, now appears likely. For campsites and trailer parks - which are especially vulnerable to tornado damage - some special provisions may be warranted.

....

The federal and other levels of government must realise that present levels of funding to their operational and research science based agencies are seriously limiting their ability to provide necessary public services. In the present context this means weather forecasts and warnings, on land and at sea, air quality and climate research and monitoring; but almost all areas of government science are hurting and the provision of quality service to the public is becoming increasingly difficult or impossible to maintain."

I left out some of the "budget-cut bleating", as Bob Jones sagely characterised it, but it is important for all of us, as members of the public with special expertise in these areas, to realise and expound the view that cuts in funding to MSC, DFO and provincial agencies are leading to serious stresses in the scientific and technical public service and that they need and deserve better treatment. Write to your MPs and MPPs, harass them at meetings and lobby! In this context you should note that CMOS are active participants in the Partnership Group for Science and Engineering (PAGSE - see www.pagse.org) and are considering membership of the Canadian Consortium for Research as a means of pressing government for support of science. But direct input from individual constituents and voters is also needed; give that some thought if you have time once summer is over.

Peter Taylor,
President / Président

Next Issue - Prochain Numéro

Next issue of the *CMOS Bulletin SCMO* will be published in October 2000. Please send your articles, notes, workshop reports or news items at the earliest to the address given on page ii. We have an **URGENT** need for your articles.

Le prochain numéro du *CMOS Bulletin SCMO* paraîtra en octobre 2000. Prière de nous faire parvenir au plus tôt vos articles, notes, rapports d'atelier ou nouvelles à l'adresse indiquée à la page ii. Nous avons un besoin **URGENT** d'articles.

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Sheila Bourque

Air Quality Research Needs in Canada

by Dr. Diane Michelangeli[1]

Résumé: Récemment des études épidémiologiques et des études sur la santé ont montré que certains polluants qui sont habituellement mesurés dans l'air atmosphérique, peuvent être reliés à l'augmentation des problèmes de santé. Le smog consiste en une brume sèche d'un brun jaunâtre et se forme lors de journées très chaudes lorsque les oxydes d'azote (NOx) et les composés organiques volatiles (VOCs) réagissent au rayonnement solaire. Un résultat de ces réactions, c'est la formation d'ozone. Les matières particulaires fines (PM) ou les aérosols sont aussi des éléments additionnels au smog. À la fois, l'ozone et les matières particulaires ont été reliés aux problèmes de santé comme les symptômes respiratoires aigus, l'augmentation des cas d'asthme, les bronchites chroniques et la mort prématurée. En particulier, les aérosols plus fins (PM10 et PM2,5, qui ont des diamètres aérodynamiques inférieurs à 10 µm ou 2,5 µm, respectivement) sont d'une grande préoccupation, car ils pénètrent plus profondément dans l'appareil respiratoire. Tandis que l'ozone est le résultat de réactions chimiques dans l'atmosphère, les matières particulaires peuvent être émises toutes les deux directement (Primaire PM) ou peuvent être formées par des réactions dans l'atmosphère (Secondaire PM) impliquant les dioxydes de souffre (SO2), les NOx et les VOCs. La réduction de la visibilité et les dommages causés aux cultures sont aussi d'autres effets du smog. Les données actuelles obtenues des stations canadiennes de surveillance de la qualité de l'air montrent que l'ozone et les matières particulaires excèdent les concentrations ambiantes et sont responsables d'effets sur la santé selon des statistiques fiables. Des études récentes semblent suggérer qu'il n'y a pas de seuil inférieur pour les effets sur la santé. La mesure standard pour l'ozone est une concentration moyenne horaire de 82 parties par milliard, et cette mesure a été dépassée au moins une fois dans presque chaque ville d'importance au Canada, au cours des 20 dernières années. Les cas les plus fréquents de violations d'ozone du niveau acceptable ont lieu dans la vallée du Bas Fraser en Colombie-Britannique, dans le corridor Windsor/Québec et sur le sud de la région de l'Atlantique.

Introduction

Recent health and epidemiological studies have shown that certain pollutants, which are routinely measured in ambient air, can be linked to increased health problems. Smog, which consists of a yellowish-brown haze, is formed on hot summer days when Nitrogen Oxides (NO_x) and Volatile Organic Compounds (VOCs) react in the presence of sunlight. One result of the reactions is the formation of ozone. An additional component of Smog is the fine Particulate Matter (PM), or aerosols. Both ozone and PM have been linked to health problems, such as acute respiratory symptoms, increased incidences of asthma, chronic bronchitis and premature mortality. In particular, the finer aerosols (PM_{10} and $PM_{2.5}$, with aerodynamic diameter less than 10 μm or 2.5 μm, respectively), are of greater concern, because they travel deeper into the respiratory system. While ozone is the result of chemical reactions in the atmosphere, PM can be both emitted directly (Primary PM) or can be formed by reactions in the atmosphere (Secondary PM) involving sulphur dioxide (SO_2), NO_x and VOCs. Other effects of Smog include reduced visibility and crop damage.

Note from the Author

On November 16th, 1999, Dr. Diane Michelangeli, Associate Professor of Atmospheric Science at York University, gave a presentation in Ottawa to the Members of Parliament during a session of the *Bacon and Eggheads Breakfast Series*. The seminar, entitled *"How is our Atmosphere Impacting the Quality of Life in Canada? A Review of Current Research Areas of Concern."* was intended to provide a brief overview of atmospheric science issues of concern, to outline contributions of some of the Canadian scientists to the field, and to describe some of the outstanding questions needing further research. During the presentation, the specific areas discussed were Climate Change, Acid Rain, Smog and Particulate Matter (PM), Stratospheric Ozone and Severe Weather Patterns and Storms. For each of those atmospheric issues, there are possible negative economic, ecological and health impacts resulting from human activities. The purpose of the article presented here is to summarize the section of the presentation related to Smog and PM, and to provide some updates on new regulations. It is important to note that this article was not intended to be a comprehensive review of the accomplishments of Canadians in the atmospheric sciences, and therefore may have omitted unintentionally some important efforts.

Current data from Canadian air quality monitoring stations show that ozone and PM exceed the ambient concentrations at which there are statistically significant health impacts. Recent studies seem to suggest that there is no low threshold for health impacts. The current standard for ozone is a one hour average concentration of 82 ppb, which was exceeded at least once in almost every major city in Canada over the last 20 years. The highest incidences of ozone violations of the acceptable level occur in the Lower Fraser Valley in British Columbia, the

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Windsor-Québec Corridor and the Southern Atlantic Region.

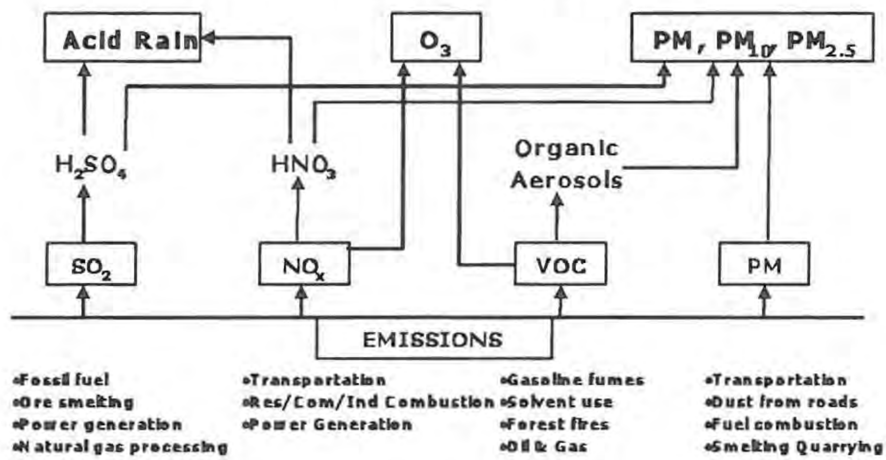
Current Research Issues

In order to understand all aspects of PM and ozone, as well as other atmospheric issues such as climate change, acid deposition and toxics, there must be research activities in the laboratory, in the field and in computer modelling. Each one of these components is critical in the fundamental understanding of the processes that control the formation of PM and ozone. Laboratory studies are needed to determine reaction rate constants, product yields, surface properties, compositions of aerosols and to test field instruments. Ambient measurements obtained during focussed field campaigns or on-going long-term monitoring programs are essential to test model predictions, validate models, test and improve instruments. The long-term data are critical to evaluate trends and the possible impacts of emission control strategies.

Physically based atmospheric models are the primary tools used in routine, operational weather and climate forecasts. Scientists use models to collate all the process information and data available, in an attempt to simulate the atmospheric behavior in the most realistic way possible. Models can be as simple as simulating chemical and physical processes only as a function of time (0-D), or as a function of time and 3 dimensional space. The scales of the atmospheric models vary from a few hundred metres to global. Each model is designed to address specific scientific questions. Model development can be as time- consuming as the development of new laboratory techniques or instruments. The larger and more complex the models, the more difficult they are to maintain, upgrade and test. The modelling component of atmospheric research is very important, because it helps test our understanding of the interactions (diagnosis) among the various components of the atmosphere. Predictions (prognosis) of the impacts of expected changes can only be made with accurate, state-of-the-art models. All models contain parameterizations of processes that occur at scales that the model cannot resolve. This can mean that there may be specific issues (i.e. colder temperatures, lake/sea breezes, mountains, emissions and surface properties) for which the models developed for other geographical locations may not work very well. It is therefore important to have Canadian models specifically designed to address our policy needs for the future.

The key issue, and scientific question driving air quality research is the interaction between the various atmospheric components of emissions, meteorology and chemistry. Figure 1 attempts to illustrate, in a simplified schematic, the relationships between the key elements of air quality. Emissions of SO_2, NO_x, VOCs and primary PM (elemental carbon, sea salt) will each contribute to at least two air quality issues such as acid rain, ozone and PM. SO_2 forms sulphuric acid (H_2SO_4) which is a critical component of acid rain and forms particulate sulphate. NO_x forms nitric acid (HNO_3) which also contributes to acid rain and PM. In addition, NOx plays a critical role in ground level ozone formation. VOCs contribute to ozone formation, and also can form organic aerosols in mechanisms that are highly uncertain at this time. In addition to these chemical interactions, there are also heterogeneous reactions that occur between the gases and the surface of the aerosols, and aqueous phase reactions occurring in aerosols and cloud drops.

Figure 1 Acid Rain, Smog, Particulate Matter - Interrelated Regional Problems



As we learn more about the atmosphere, our understanding of its complexity increases. For example, in the stratosphere, we now know that heterogeneous reactions on the surfaces of the polar stratospheric clouds play a key role in the Polar ozone depletion. We have also seen in the stratosphere that sulphate aerosols, formed as a result of volcanic eruptions (i.e. El Chichon and Mount Pinatubo) seemed to have had an impact on the ozone concentration. Aerosols can also affect atmospheric chemistry by changing the radiation field, thereby changing temperature and photolysis rates. We can also expect dynamical changes as a result of changes in aerosol levels through changes in condensation nuclei, clouds and radiation.

Table 1: Ozone and $PM_{2.5}$ Changes from NO_x and VOC Reductions

No_x Reductions	Pollutant Changed	VOC Reductions 0 %	25 %	50 %
0 %	Ozone	0 %	- 19 %	- 34 %
	$PM_{2.5}$	0 %	+ 18 %	+ 19 %
25 %	Ozone	- 2.6 %	- 4 %	- 6 %
	$PM_{2.5}$	-9 %	-9 %	- 7 %
50 %	Ozone	- 6 %	-17 %	-25 %
	$PM_{2.5}$	-18 %	- 9 %	- 15 %

Source: Meng, Dabdub, Seinfeld, Science, 277, p116, 1997.

As a support to policy makers, the question of the non-linear chemical effects of changing emissions is very important. In 1997, Meng, Dabdub and Seinfeld (Science, Vol. 277, p. 116) presented model results investigating the impacts of NO_x and VOC control strategies on ozone and $PM_{2.5}$.

An excerpt of their results is presented in Table 1. They varied VOCs and NO_x emissions by 0%, 25% and 50%, and looked at the changes in ozone and $PM_{2.5}$ concentrations. In the case where NO_x did not change and VOC was reduced by 50%, ozone decreased by 34%, but $PM_{2.5}$ actually increased by 19%. In the case where VOCs were not changed but NO_x was reduced by 50%, the loss of ozone was only 6%, and $PM_{2.5}$ decreased by 18%. An additional reduction of VOCs of 50% only resulted in a 15% $PM_{2.5}$ decrease. These model results indicate clearly the complexity of the gas-particle interactions. In order to develop sound policy decisions and the best means of meeting the new CWS (Canada-Wide Standards), further research is clearly necessary to understand the impacts expected. At this stage, very little is known regarding emission levels, the particle formation processes (especially for the organic aerosols), the composition of the aerosols, and the heterogeneous reactions. One of the key issues of interest to the Canadian Stakeholders is the relationship between the sources of the emissions, and the ambient concentrations of ozone and PM at the receptors. In order to help industry develop sound, cost-effective reduction strategies, source-receptor models are necessary.

What is Canada doing?

In order to address national and regional air quality issues, the Federal and Provincial governments are setting new standards and guidelines, and revising and updating existing ones. The results of new health and atmospheric research are taken into consideration, along with socio-economic issues, during the process of setting policies. Consistent with the Canada-Wide Accord on Environmental Harmonization, the Federal government is in the process of developing new CWS for PM and ozone. The Federal and Provincial governments have undertaken scientific and socio-economic studies to help in the implementation of the standards. On June 5-6, 2000, the Canadian Council of Ministers of the Environment (CCME) endorsed the following targets and timeframes.

"The CWS and related provisions for PM are:

> A CWS for $PM_{2.5}$ of 30 $\mu g/m^3$, 24 hour averaging time, by year 2010.
> ■ Achievement to be based on the 98^{th} percentile ambient measurement annually, averaged over 3 consecutive years."

"The CWS and related provisions for ozone are:

> A CWS of 65 ppb, 8 hour averaging time, by year 2010.
> ■ Achievement to be based on the 4^{th} highest measurement annually, averaged over 3 consecutive years."

In addition, there are specific provisions related to transboundary flow of ozone. In the development of the new CWS, the CCME has built in a review process. By the end of 2005, after additional scientific, technical and economic analyses, the standards will be revised or supplemented. In 2010, a further assessment of the need for the standards and the success of their implementation will be completed. This review process, clearly outlined by the CCME, highlights the importance of on-going scientific research on the formation and evolution of PM and ozone.

Because of the regional (transboundary) and global extent of air quality problems (toxics and metals, chlorofluorocarbons, greenhouse gases and other longlived species), the Canadian government has adhered to international treaties and protocols (i.e. Montréal Protocol, The U.S.-Canada Accord, etc.).

Canadian scientists participate actively in projects of international scope. For example, the creation of the MOPITT (Measurements of Pollution in the Troposphere) instrument at the University of Toronto, which is now flying on NASA's TERRA satellite, has ensured that Canadian scientists will have detailed understanding of the most comprehensive global tropospheric chemical data set available. The involvement of York University scientists in this project has encouraged the development of state-of-the-art atmospheric global chemical modelling capacity in Canada. Other current satellite and modelling projects in which Canadian scientists are actively involved include ACE (Atmospheric Chemistry Experiment) led by the University of Waterloo, Picasso-Cena (NASA/CNES aerosol backscatter experiment with participation in data assimilation by York University, the Meteorological Service of Canada (MSC) and a few other Canadian scientists) and ODIN, a Swedish-led satellite mission with a Canadian instrument OSIRIS led by the University of Saskatchewan, to study global ozone. Canadian participation in the satellite projects ensures that we remain current with all technical and scientific advancements. Our history in space has proven to be very successful, with the long-term WINDII (Wind Imaging Interferometer) mission that has been sending data back to our scientists since 1991.

On a North American regional scale, Canada was involved with the EMEFS program in 1988-1990, which consisted of an extensive monitoring program and several intensive field campaigns in the North-Eastern U.S. and Canada, designed for regional ozone model evaluation. Canada has been an active participant in NARSTO (the North American Research Strategy for Tropospheric Ozone).

At a national level, in order to evaluate the long-term trends and understand formation and evolution processes for acid rain, ozone and PM, the Federal and Provincial governments maintain active monitoring programs. PM has been measured routinely since 1970, with increasing numbers of stations recording both PM_{10} and $PM_{2.5}$ levels. Other pollutants such as CO, NO, NO_2, SO_2, VOCs and metals are measured at selected locations. Canada has been contributing to the global greenhouse gas monitoring network with routine measurements at Alert and Sable Island since 1975. Canadian scientists developed the automated Brewer ozone spectrometer, which has proven to be a very accurate and stable ozone-measuring instrument, operating in over 35 countries and twelve sites in Canada. As a result of active research on ozone, Canada created the Ultra-Violet (U.V.) Index, which has been adopted by the World Meteorological Organization and the World Health Organization and in over 20 countries.

In addition to the on-going monitoring programs, there have been, and continue to be, a number of Canadian field campaigns that focus on a particular region and scientific issue. These field studies tend to be local or regional in spatial extent, and last a few weeks. The maximum number of scientists are encouraged to participate, so that an extensive suite of instruments can be deployed. These focussed field campaigns tend to be a good forum for instrument and technique tests, and performance evaluations. From the scientific perspective, they often allow scientists to further their understanding of specific atmospheric processes. A few of these field studies include the Canadian Northern Wetland study in 1989 that focussed on greenhouse gases and climate change, the Polar Sunrise Experiment (1998) that focussed on Arctic Processes, and SONTOS (Southern Ontario Oxidant Study, 1992, 1993, 1996) that tried to understand smog formation and evolution. Pacific 93, a large field campaign in the Lower Fraser Valley, as well as the one organized in the Southern Atlantic Region as part of NARSTO (1996), both focussed on smog in these areas. Pacific 2001 is now in the planning stages, and will involve scientists from Universities and governments in a massive west-coast effort, with particular focus on PM. The large interest in the science of PM has lead the Centre for Atmospheric Chemistry (CAC) at York University to undertake a series of focussed field studies in Southern Ontario in the summers of 1999, 2000 and 2001. In collaboration with the Ontario Ministry of Environment, an extensive number of measurements have been and will be taken, and measurement methods are being developed and tested to understand the processes governing the formation and evolution of PM, and their interactions with the gases.

Whether it be data from long-term monitoring programs or focussed field campaigns, they are critical for model initialization, testing and evaluation processes. Without specific Canadian data, and models developed to reproduce these data, forecasts of future air quality trends and the evaluation of the results of government policy decisions are impossible. Because of the multiple scales (spatial and temporal) of the different chemical, dynamical and microphysical processes, many models have been developed. There are a number of box (0-D) and 1-D models used for specific process studies. More complex 3-D models have been developed in Universities and in the government laboratories (MSC and the National Research Council (NRC)) to address certain scientific questions, and for operational ozone forecasting.

Canada has one of the most advanced General Circulation Models in which ocean coupling is included to allow for more realistic climate change studies (Canadian Centre for Climate modelling and analysis, CCCma). The Canadian Middle Atmosphere Model (CMAM), which is a global climate model with emphasis on the middle atmosphere (stratosphere and thermosphere), now includes chemistry interactively from the surface to 95 km. This model can now be used for detailed ozone, aerosol, dynamical feedback studies, answering important questions related to the lower and upper atmosphere. The NARCM model (Northern Aerosol Regional Climate Model) was developed to study aerosol processes in the Polar region. MSC and the Université du Québec à Montréal (UQAM) collaborated in the development of a state-of-the-art mesoscale community weather forecasting model (MC2) which has been used extensively around the world. Recently at York University it was used at high resolution to study the initiation of small scale severe storms by converging lake breezes in Southern Ontario. Chemistry has been included in MC2 in a way that permits interactive feedback between chemistry and dynamics, to allow for regional tropospheric ozone modelling based on good meteorological predictions (MC2AQ). In addition, MSC is in the process of developing A Unified Regional Air Quality Modelling System (AURAMS) based on combining MC2 as the meteorological driver, a chemical transport model (CHRONOS), an aerosol module (CAM, developed under NARCM) and an emissions processing system (CEPS). The goal of AURAMS development is to provide a modelling system that can deal with multiple air quality issues to support the new government policies and air quality predictions in the long run. In addition, other modelling efforts are currently under way at York University with other models to understand the impacts of aerosols on regional and global chemistry. Other air quality efforts are taking place, for example, collaborations between the University of Waterloo and the Ontario Ministry of the Environment (OME) and also between the NRC and a private sector company, to adapt the U.S. Environmental Protection Agency (U.S.EPA) Models-3 to Southern Ontario conditions. Running this modelling system can be useful for comparison purposes; however, since it has not yet been validated with Canadian data, it would be premature to use it in the Canadian context for policy decisions at this time.

For accurate air quality predictions, accurate forecasting of meteorology is critical: thus the evolution of air quality models must be closely linked to the evolution of weather forecasting models. The meteorology must be well understood and simulated so that the formation and evolution of the pollutants can be well predicted. It is for this reason that the atmospheric chemistry community must be closely linked to the meteorological community. The efforts at the MSC regarding the developments of a weather forecasting model will be focussed on the Global Environmental Multiscale (GEM) model. This global model, which can be run at regional scales, includes similar physics as MC2, with an added advantage of being upgraded with data assimilation capabilities. With the positive future of numerous satellite missions providing global chemical and dynamical data sets of high quality and resolution adequate for regional studies, the data assimilation feature of a model becomes very important. The focus of the Canadian air quality modelling community will most likely turn towards the integration of detailed chemical and microphysical processes within GEM. This state-of-the-art model will be developed to serve the Canadian community at large.

Conclusions - What needs to be done?

Improving air quality for all Canadians in a way that will be scientifically and economically sound will require better understanding of the impacts of human actions on the atmosphere. This fundamental understanding, which will lead to better predictive capability, may be acquired by improving the models that integrate all the known processes. The models have to be continuously evaluated, otherwise we cannot have confidence in the predicted results. This evaluation process, understanding of the fundamental processes taking place, and quantifying impacts of changes can best be achieved by well-designed long-term monitoring programs, and focussed field studies. Specific focus on aerosols will be necessary due to the vast level of uncertainty regarding their formation and evolution processes. The monitoring and field programs have to be supported by laboratory studies that will lead to instrument development and understanding of processes. Active participation in international satellite programs and data assimilation are key to successful global model development.

Some of the specific air quality questions that remain to be addressed include: testing of impacts of the current and future U.S. and Canadian emissions reduction measures, investigating additional control levels needed to meet the acid precipitation targets, deciding on best locations for monitoring sites, evaluating the implications of diverse regional emissions control strategies, improving emissions inventory processing, developing Canadian source-receptor relationships for PM and ozone, improving our understanding of transboundary transport, and increasing our fundamental knowledge of the effects of pollutant interactions.

We know that there are significant impacts of humans on the atmosphere and of the atmosphere on our health and the environment. The study of atmospheric science is interdisciplinary and involves a wide range of time and space scales. The issues will be resolved by improving our understanding of chemistry, dynamics, microphysics and radiation. The scientific measurements and modelling studies will answers questions and therefore, there must be a continuous dialogue between science and policy decisions.

Acknowledgements

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The McGill Paleoclimate Model (MPM): A New Earth System Model of Intermediate Complexity

by

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Résumé: Le climat a changé dramatiquement au cours des temps et lieux pendant l'histoire des 4,6 milliards d'années de la Terre. Au cours de ces temps géologiques, la Terre a traversé des périodes plus chaudes et plus froides qu'aujourd'hui. Dans la littérature des sciences de la terre, ces longues périodes (plusieurs millions d'années) sont appelées "période de serre chaude" et "période igloo", respectivement. De plus, au cours de ces phases chaude et froide, des fluctuations climatiques sur de grandes amplitudes d'échelles de temps, se sont produites. Un grand défi pour la communauté scientifique environnementale, c'est de comprendre pleinement et de prévoir finalement ce comportement dynamique. Ceci peut se réaliser à travers le développement et l'application des modèles du système Terre qui renferment des éléments variés de la géosphère et de la biosphère. Puisque des modèles complets (3-D) de la circulation générale avec couplage atmosphère/océan/surface terrestre ne peuvent pas être intégrés sur des dizaines de milliers d'années, nécessaires pour une étude de l'évolution de ces climats et de leurs fluctuations, nous devons recourir à l'utilisation de modèles plus simples du système Terre. Une telle catégorie de modèles qui a connu beaucoup d'intérêts au cours de ces dernières années, c'est le modèle du système Terre de complexité moyenne (Claussen et al. 2000) : "Earth system Model of Intermediate Complexity - EMIC". Le but principal de cet article, c'est de décrire le schéma EMIC à cinq éléments qui a été développé récemment à McGill et qu'on surnomme le Modèle Paléoclimatique de McGill (MPM).

1. Introduction

The climate has varied dramatically over time and place during the 4.6 billion-year history of the Earth. On this geological timescale, the Earth has passed through much warmer and much cooler periods than today. In the earth science literature, these lengthy (several million-year) periods are called "greenhouses" and "ice houses", respectively. Further, within these warm and cold phases, climatic fluctuations on a wide range of timescales have occurred. A great challenge for the environmental scientific community is to fully understand and ultimately predict this dynamic behaviour through the development and application of Earth system models which encompass the various components of the geosphere and the biosphere. Since comprehensive (3-D) coupled atmosphere-ocean-land surface general circulation models cannot be integrated for the tens of thousands of years required for the investigation of the evolution of these climates and their fluctuations, we must resort to the use of simpler Earth system models. One such class of models which has received considerable attention in the past few years is the EMIC: Earth system Model of Intermediate Complexity (Claussen et al. 2000). The main purpose of this article is to describe a five-component EMIC that has recently been developed at McGill, the so-called McGill Paleoclimate Model (MPM).

EMICS generally describe many of the processes contained in comprehensive 3-D models, but in a more parameterized form. They explicitly simulate interactions among several components of the Earth system. However, because of their coarse resolution, simplified geography and sometimes reduced dimensionality, EMICs can be integrated on a workstation to simulate the behaviour of the Earth system over tens of thousands of years or even over 100-ka glacial cycles. Nonetheless, the degrees of freedom of an EMIC greatly exceed the number of adjustable parameters in the model, and in this way EMICs are more sophisticated than simple "conceptual" or "box" models of the Earth system. The latter models describe fewer processes than EMICs and are spatially highly aggregated. For example, in the simple coupled atmosphere-ocean model of Nakamura et al. (1994), the atmosphere is represented by two boxes, and the ocean, by three. Because they are not limited by computational costs, box models have been widely used in the past for many climate and paleoclimate studies, including the development of future climate scenarios due to anthropogenic forcing. However, because they lack many important climate processes and feedbacks and do not maintain the geographic integrity of the land-ocean configuration, box models are not as useful as EMICs in exploring the wide range of interactions among the components of the Earth system.

The development of EMICs in various climate research centres around the world started roughly a decade ago, and today there is now an active group of EMIC modellers which meet once or twice a year to exchange notes on selected results from the models and to plan intercomparison simulation experiments. The last EMIC group meeting, held during the 25th General Assembly of the European Geophysical Society in Nice (April 24-29, 2000), attracted over 30 participants. At this meeting,

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representatives of about 10 EMIC modelling centres described, for the first time, the details of the components that made up each EMIC.

The next major project of the EMIC modellers is to prepare an overview paper (Martin Claussen, lead author) which will describe 10 EMICs that are currently in use for either paleoclimate studies or the simulation of future climate scenarios. For this purpose, a template has been designed which will give for each EMIC, its scope, the model components and performance, and selected applications. The contributing authors for this article are now in the process of describing two EMICs from Belgium (Crucifix et al. 2000; Goose et al. 2000), two from Canada (Eby et al. 2000; Wang and Mysak 2000b), two from Germany (the Hamburg "Planet Simulator", G. Lohmann, pers. comm. 2000; Petoukhov et al. 2000), and one each from Russia (Handorf et al. 1999), Switzerland (Marchal et al. 1998), the Netherlands (Opsteegh et al. 1998) and the USA (Kamenkovich et al. 2000). From a preview of a first draft of descriptions of these models, it is apparent that the 10 EMICs are further subdivided into two classes: (1) Those in which all the model variables are sectorially or zonally averaged across the different ocean basins and continents or subcontinents (Crucifix et al. 2000; Marchal et al. 1998; Petoukhov et al. 2000; Wang and Mysak 2000b). (2) Those (the remaining six EMICs) that employ a coarse resolution 3-D ocean model (such as Pacanowski 1995; Maier-Reimer et al. 1993) which is coupled to a simplified atmospheric model (e.g., see Eby et al. 2000; Kamenkovich et al. 2000) or a coarse resolution 3-D atmospheric model (e.g., as in the Hamburg EMIC which uses the Fraedrich et al. (1998) AGCM; Goose et al. 2000).

The remainder of this paper is structured as follows: in the next section we outline the scope of the MPM, and in section 3 the model components and performance are described. A brief review of past applications of the MPM (or reduced versions of it) is given in section 4, and in section 5 a perspective on EMICs and future work involving the MPM is presented.

2. Scope of the MPM

The MPM is a coupled atmosphere-ocean-sea ice-land surface-ice sheet model which has been incrementally developed over the past decade for the purpose of a) investigating long-term (greater than decadal) climate changes, and b) simulating paleoclimates at different time slices of Earth history. The MPM includes the seasonal cycle, and it resolves three ocean basins (the Atlantic, Pacific and Indian Oceans), the Antarctic Circumpolar Current region and the major continents. The land-ocean configuration used in the model is shown in Fig. 1 (Wang and Mysak 2000a). In each latitude band between 75° N and 75° S, the model variables in the five components are sectorially averaged across the different ocean basins and continents. In its current form, the five-component MPM has been used to investigate millennial-scale ice sheet-THC interactions (Wang and Mysak 2000b) and the nature and stability of the THC (Wang et al. 2000) during a range of glacial conditions of the Quaternary period. However, in the future the model will be applied to other geological periods.

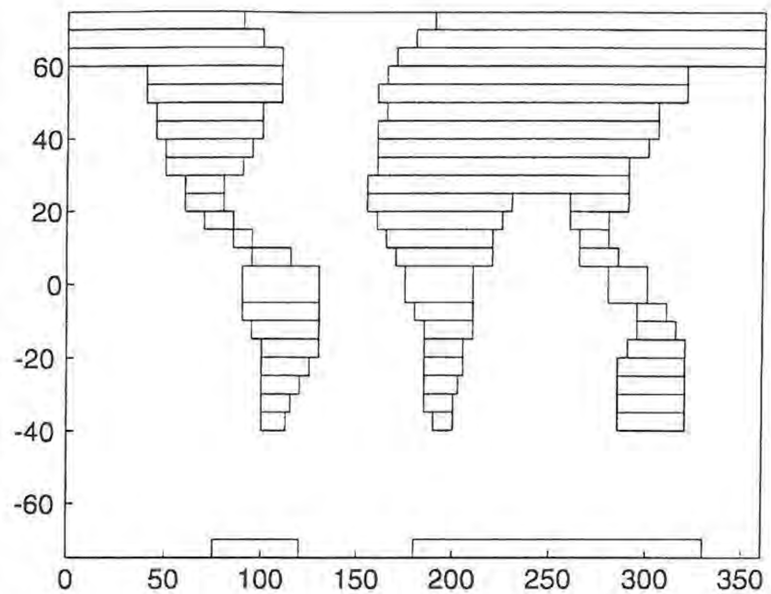

Fig. 1. Land-sea configuration used in the MPM

3. Model Components and Performance

The atmosphere in the MPM is represented by an energy moisture balance model (EMBM) based on Fanning and Weaver (1996), in which meridional energy and moisture transports are parameterized by a combination of advective and diffusive processes. The zonal transport of heat obeys a diffusion law, while the zonal moisture transport is parameterized so that the ocean always supplies moisture to the land (Wang and Mysak 2000a). This model component is forced by the monthly mean solar insolation at the top of the atmosphere (Berger 1978).

The ocean component is based on the zonally averaged THC model of Wright and Stocker (1991) and Stocker and Wright (1991), which was originally developed at McGill a decade ago. The zonally averaged east-west pressure gradient is parameterized in terms of the meridional pressure gradient, as in the original paper of Wright and Stocker. More physically based parameterizations for the zonally averaged east-west pressure gradient have been introduced (e.g., Wright et al. 1995); however, for ocean basins of uniform depth they do not give qualitatively different results on the structure of the THC. The time evolution of the ocean temperature and salinity are described by advection-diffusion equations, and the velocity components are diagnosed from the zonally averaged momentum equations and the continuity equation. The equation of state is nonlinear, and the convective adjustment is taken from Schmidt and Mysak

(1996a). Further details on the ocean model and its coupling to the EMBM can be found in Bjornsson et al. (1997).

For the sea ice component of the MPM we employ a zero-layer thermodynamic model without snow in which the ice surface temperature and mean thickness are calculated according to Semtner (1976), and the sea ice concentration is predicted using the method of Hibler (1979). In addition, the zonally averaged advection velocity of sea ice is prescribed according to Harvey (1988).

In the land surface model, the surface temperature for either snow-free or snow-covered conditions is predicted by an energy budget equation, similar to that of Ledley (1991). The hydrological cycle for snow-free and snow-covered land is simulated using the classic bucket model (Manabe 1969). Further details on the above four model components and how they are coupled together in the MPM are given in Wang and Mysak (2000a).

The fifth component of the MPM, the ice sheet model, is a modification of that presented in Gallee et al. (1992). The ice sheet thickness is predicted by an ice mass conservation equation. The meridional ice flow velocity component is diagnosed from the ice sheet height, and the bedrock depression is predicted using the local damped isostasy model (e.g., Peltier and Marshall 1995).

The model resolution is 5 degrees in the meridional direction for all the model components except the ice sheet component, which has a 0.5 degree resolution. The time steps are 6 hours for the atmosphere, land surface and sea ice components, 15 days for the ocean model and 10 years for the ice sheet model. At the present time, a 30-ka integration takes approximately 24 hours on our workstation, which is an IBM RS6000/260.

In terms of physical processes and mechanisms, the MPM has obvious limitations: a) The surface wind and meridional ice velocity are prescribed; b) Ice sheet thermodynamics is neglected; c) The model domain extends only to 75° N and 75° S – hence there is neither an Arctic Ocean nor an Antarctic continent; d) The water vapor-temperature feedback is neglected. Another shortcoming of the current version of the MPM is the absence of a biospheric component, which is, however, included in several other EMICs (eg, Marchal et al. 1998; Petoukhov et al. 2000). Thus the vegetation-albedo feedback (e.g., Claussen et al. 1999) and the carbon cycle are not present in the MPM.

4. Applications

The first application of a much simplified version of the MPM was made at McGill by Stocker et al. (1992). They employed a three-basin version of the Wright and Stocker (1991) THC model coupled to a traditional annual-mean energy balance model (EBM) of the atmosphere (Sellers 1969) to investigate the effect of prescribed freshwater discharge into the North Atlantic on the THC. Thus this was a prototype of many later Younger Dryas cooling experiments with coupled atmosphere-ocean GCMs (e.g., Manabe and Stouffer 1997). However, our subsequent increased knowledge of climate processes on multi-decadal and longer timescales led to the realization that for such studies, an active hydrological cycle should be incorporated into coupled atmosphere-ocean models, including those of the EMIC class. This was done in the pioneering paper of Fanning and Weaver (1996), where the EMBM was first presented and coupled to an OGCM (Pacanowski 1995).

A zonally averaged version of the Fanning and Weaver EMBM was coupled by Schmidt and Mysak (1996b) to the Wright and Stocker THC model (with, however, the convection scheme of Schmidt and Mysak (1996a)) in an ocean domain that was derived from the land-ocean configuration of the mid-Cretaceous (100 Ma BP), a period of the dinosaurs. The Schmidt and Mysak (1996b) investigation was thus the second application of a reduced version of the MPM. The mid-Cretaceous was singled out for study by Schmidt and Mysak because it was the last major "greenhouse" (with a very high concentration of atmospheric CO_2) for which accurate ocean paleoclimate data can be obtained. These data indicate that the global mean temperature may have been 6 to 12° C warmer than today, and that the Earth's climate was very equable (i.e., there was a small equator-to-pole temperature gradient and no ice present in the polar regions). Thus a fundamental question is: what produced this weak temperature gradient? Schmidt and Mysak (1996b) showed that in addition to large sensible and latent poleward heat transports in the atmosphere, there could have been large poleward heat transports in the ocean (up to 2 PW), mainly due to the THC. The total model poleward heat transport was estimated to be at least 7 PW, which is about 2 PW more than is observed today. Another important reason for studying the environment of the mid-Cretaceous was that this was a time of wide-spread episodes of organic-carbon burial in marine sequences, resulting in the formation of an estimated 70% of the world's reserves of oil and gas.

The next (third) application of an early version of the MPM was made by Bjornsson and Mysak (2000) who investigated the nature and stability of the THC during the Last Glacial Maximum (LGM) at around 20 ka BP. This was a time of extreme cold, and paleoceanographic data suggest that there was reduced North Atlantic Deep Water (NADW) formation and hence likely a weaker THC in the North Atlantic Ocean (Boyle 1995). In Bjornsson and Mysak a thermodynamic sea ice model was added to the coupled atmosphere-ocean model used by Schmidt and Mysak (1996b), but in a three-ocean domain similar to that employed by Stocker et al. (1992). Bjornsson and Mysak found that because of the simulated extensive sea ice cover in the North Atlantic, NADW formation took place further south than today and that indeed, the maximum intensity of the THC was reduced by about 2 Sv, in qualitative agreement with the observations.

The current version of the MPM (less the ice sheet component), described in Wang and Mysak (2000a), was first used to simulate the present-day climate. With the employment of flux adjustments for heat and freshwater, the major features of the simulated climate are consistent with observations and the general results of GCMs (see Figs. 3 and 4 in Wang and Mysak (2000a). This four-component model was then used by Wang and Mysak (2000a) to investigate the initiation of glaciation around 115 ka BP, by reducing the solar radiation and increasing the planetary emissivity, only in northern high latitudes. This was done to simulate Milankovitch cooling and a lower CO_2 concentration in the atmosphere. One of the main results found in this fourth application of the MPM is that when land ice is growing, the THC in the North Atlantic is intensifed, which produces a warm subpolar North Atlantic Ocean, in agreement with the observations of Ruddiman and McIntyre (1979). The intensified THC maintains a large land-ocean thermal contrast at high latitudes and hence enhances land ice accumulation.

The full five-component MPM was next employed to study Quaternary ice sheet-THC interactions (Wang and Mysak 2000b). This paper is an extension of results presented in Wang's 1999 PhD thesis for which he received the Tertia Hughes Memorial Prize from CMOS. In this version of the MPM, massive iceberg calvings (representative of "Heinrich events") are prescribed to occur when the maximum ice sheet height in North America reaches a critical value. Using this crude iceberg calving mechanism, millennial-scale climate cycles are simulated as follows: for a sufficiently large calving event, the THC may be shut down in the North Atlantic, which causes a large climate change in this region. Because of the equatorward advance of sea ice, there is a significant cooling in the northern high latitudes and a large reduction in the net accumulation rate at the grid of maximum ice sheet height in North America. When the collapsed THC is restored (by increasing the vertical diffusivity in the North Atlantic Ocean), we find a large retreat of sea ice extent and hence a significant warming in northern high latitudes and a subsequent increase in the net accumulation rate at the grid of maximum ice sheet height. The latter process can then lead to another large iceberg calving event, some 2-3 ka after the first event. This periodicity, however, is shorter than that generally associated with Heinrich events (5-10 ka).

Lastly, the THC response to various cold climates has been investigated as a sixth application of the MPM by Wang et al. (2000). In this paper it is shown that the response of the THC to global cooling is nonlinear. For a slightly cold climate, the North Atlantic overturning cell (NAOC) and the Pacific upwelling become intensified. For a very cold climate, the NAOC may be weakened or even collapsed. The associated Pacific upwelling for a very cold climate also becomes weak when the NOAC is weakened. When the NAOC is collapsed, intermediate water may form in the Pacific. We are now searching for evidence of these different states of the THC in various paleoceanographic data sets.

5. Perspective and Future Work

Studies of the Earth system generally involve a hierarchy of models. Depending on the timescales and questions of interest, one can obtain useful information from simple conceptual or box models. At the other extreme, comprehensive 3-D coupled GCMs are necessary for obtaining detailed information on climate processes on regional scales as well as on the global scale. However, they cannot be used for long integrations to answer important questions about the evolution of paleoclimates or for studying the interactions among all the components of the Earth system. Consequently, it has now become recognized (Claussen et al. 2000) that EMICs, Earth system Models of Intermediate Complexity, can be very valuable tools for exploring a wide range of interactions and feedbacks in the natural Earth system and for getting a deeper understanding of paleoclimates. Further, it is now accepted that the results from EMICs are more realistic than those from simple models.

With this perspective in mind, we are encouraged to proceed with the further development of the MPM and its application to other geological periods. As mentioned at the end of section 3, there are a number of limitations of the MPM and some of these could well impact on our first results on ice sheet-THC interactions (Wang and Mysak 2000b).

Currently we are investigating the impact of using, near the southern ice sheet edge, a higher resolution for the land surface component of the MPM. We are also searching for an improved iceberg calving mechanism which may include ice sheet thermodynamics. Finally, we are seeking an improved method for restoring the THC after its collapse.

With the view towards longer-period integrations (on the Milankovitch timescale), we are planning to incorporate certain aspects of the biosphere into the MPM. In particular, we would like to include the vegetation-albedo feedback and an active carbon cycle in the MPM. This would then enable us to carry out a simulation of the recent ice ages using Milankovitch forcing.

Finally, we are intrigued by the last "ice house" around 300 Ma BP, when there was a very different land-ocean configuration than today -- the paleogeography was dominated by the huge supercontinent Pangea which occupied a large portion of the southern hemisphere. Hyde et al. (1999) recently applied an ice sheet model coupled to an EBM to this geological period, known as the Permo-Carboniferous ice age. The model was successful in simulating a good portion of the observed ice sheet; however, certain discrepancies with the geological data are apparent and these may be due to the absence of an ocean component and an active hydrological cycle in the model. In the near future we plan to modify the code describing the land-ocean configuration in the MPM in order to simulate the paleogeography of this earlier glacial period, and then run the modified model to equilibrium to determine the nature and properties of the cold climate and THC at that time. At present there are no models of the THC during the Permo-Carboniferous ice age. Such a study could give us more insight into our present ice age climate and would be a good test of the robustness of the physics in the present form of the MPM. Also, this could be an important step in the development of a more comprehensive theory of major glaciations throughout Earth history (e.g., Hyde et al. 2000), and the role of the THC in this theory.

Acknowledgements

This article is based on a recent lecture ("*What can we learn from paleoclimate models?*") given by LAM at UBC's Peter Wall Institute for Advanced Studies (PWIAS) on July 25, 2000. It is a pleasure to thank William Hsieh (PWIAS Distinguished Scholar in Residence) and Ken MacCrimmon (Director of PWIAS) for their hospitality while visiting the Wall Institute in July. The authors also thank Michel Crucifix, Ian Rutherford and Greg Smith for providing helpful comments on an earlier version of this paper. LAM gratefully acknowledges the support of NSERC, AES (now MSC), CICS, ONR and FCAR for his climate research during the past decade, and ZW is grateful for the support of the Dr. and Mrs. Milton Leong McGill Major Fellowship and FCAR during his PhD studies.

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Do you know? - Savez-vous?

Les hivers seraient encore plus froids si ce n'était de la chaleur transportée des tropiques par les océans. De l'équateur à environ 30° de latitude nord, l'océan transporte plus de chaleur que l'atmosphère, et le transport océanique est encore important jusqu'à 60° de latitude nord.

Winters would be even colder were it not for the heat transported from the tropics by the oceans. From the Equator to about 30°N the ocean transports more heat than the atmosphere, and oceanic heat transports are still significant up to 60°N.

On Gordon's Retirement

Those of us who have been involved in CMOS management know how important Gordon McBean has been to the Society's success in recent years. Hearing of Gordon's retirement some of us in Ottawa were determined to deliver a message that retiring from the Federal Government is not retiring from CMOS. A special luncheon meeting of the Ottawa Centre attended by some 70 friends and colleagues was held on Thursday, June 28 at the RCAF Mess in Gordon's honour. He had been feted on his retirement from the Federal Public Service as Assistant Deputy Minister of the MSC the previous day in Downsview.

John Reid, as MC, noted that climate change, on which Gordon is a leading authority, and retirement, are both reflected in meteorological parameters. Retirement brings reduced pressure, lower humidity (no sweat), lower temperatures (less hot air), and reduced precipitation (through no longer being forced into precipitatous action on the whim of a Minister).

Ian Rutherford, Neil Campbell and Uri Schwarz reinforced the message about staying active in CMOS from their own experiences. Dick Stoddart read a short poem written by Geoff Holland.

For those who had not been in Downsview, a video of a serenade to Gordon by the IOS Opera Company was reprised. Bob Jones, on behalf of the Centre, presented Gordon with a copy of "The Joy of Not Working." To avoid giving the wrong idea, President Peter Taylor quickly followed with words of appreciation, and a certificate for a lifetime subscription to Atmosphere-Ocean.

Gordon cut a celebratory cake, featuring his portrait, as seen on the cover of this issue of the Bulletin. In a few closing remarks Gordon thanked the organizers and reflected on his career, giving every indication of continuing to be active in CMOS. Mission accomplished.

John D. Reid
Ottawa, Canada
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Gordon McBean pronounced Bain
Deserves recognition again and again
And not just because
He's a parent of GCOS
If you allow me I shall go on and explain.

Although skilled in the fine art of weather
His interests were broad and he never
Forgot other mandates
When dealing with climates
And he worked to bring all players together.

He was there at the beginning of WOCE
In fact, pre, during and post
He went on to strive for
The follow-on, CLIVAR
Showing himself more perceptive than most.

In the international arena he had gall
And argued his case large or small
Then bold as brass, he
Took on the Obasi
Well, you know that you can't win them all.

Researcher, Professor, Exec.
He's done the nation proud; I expect
One day on God's earth
We will realize his worth
And get the GG to pay his respects.

Geoff Holland
Saltspring Island, B.C.
Hollandg@saltspring.com

From all the CMOS Community, which you have served so well for so many years, have a happy and joyful retirement, Gordon.

Peter Taylor	*Neil J. Campbell*
President CMOS	*Executive Director*

Canadian Climate Models as Windows to the Future: How Credible Are They?[1]

by Henry Hengeveld[2] and David Francis[3]

Résumé: Avec la croissance énorme de la puissance des ordinateurs qui a eu lieu au cours des deux dernières décennies, les scientifiques, à la fois dans les sciences physiques et sociales, se sont de plus en plus orientés vers la modélisation mathématique comme moyen d'explorer la complexité mondiale autour de nous. Les modèles mathématiques utilisent des combinaisons entre des équations qui décrivent l'importance des relations et des processus d'un système simulant son comportement. En changeant les valeurs de quelques variables, les chercheurs peuvent voir comment le système réagit à la fois aux changements externes et internes. Comme les modèles sont une représentation simplifiée de la réalité, les résultats se doivent d'être utilisés avec prudence. Toutefois, dans plusieurs domaines, les modèles ont atteint un tel degré de fiabilité qu'ils sont couramment utilisés de façon opérationnelle et en recherche. Présentement, les modèles mathématiques sont régulièrement utilisés à des fins aussi variées que l'analyse du comportement du marché, la préparation des prévisions météorologiques, et les tests d'armes nucléaires. La recherche nous procure un moyen d'analyser des phénomènes qui ne peuvent pas être expérimentés facilement en laboratoire ou sur le terrain.

Ces modèles sont particulièrement importants en recherche du changement climatique. Notre compréhension actuelle du système climatique et la façon dont il réagit à l'augmentation des gaz à effets de serre dans l'atmosphère, seraient impossibles sans l'existence de modèles climatiques du globe ou de modèles de circulations générales, et de programmes d'ordinateurs puissants qui simulent le fonctionnement du système climatique du globe de façon temporelle et spatiale (trois dimensions). Avec l'expertise scientifique nécessaire pour élaborer ces modèles et les ressources monétaires pour faire fonctionner les ordinateurs, il n'est pas surprenant que seulement quelques pays peuvent se permettre de s'impliquer dans la modélisation climatique avancée.

Le Canada qui a été activement impliqué dans la modélisation climatique depuis le milieu des années de 1970, est un de ces pays. Cette recherche qui implique une collaboration étroite entre les scientifiques d'Environnement Canada et les universités, se fait au Centre canadien de modélisation et d'analyse climatiques à Victoria, Colombie-Britannique (Canadian Centre for Climate Modelling and Analysis - CCCma). Avec les années, les modéliseurs climatiques canadiens ont contribué de façon importante à notre compréhension des processus climatiques et du changement climatique. Comme nous entrons dans un nouveau siècle dans lequel le changement climatique pourrait devenir un des plus grands défis pour le genre humain, leur recherche devient de plus en plus importante pour la compréhension de la population et la prise de décision. La discussion qui suit, traite des derniers développements de la capacité à la modélisation climatique avec le schéma "CCCma", et les compare avec ceux qui nous parviennent de différents groupes de modéliseurs.

Introduction

With the enormous growth in computer power that has occurred over the past two decades, scientists in both the physical and social sciences have turned increasingly to mathematical modelling as a way of exploring the complex world around us. Mathematical models use combinations of inter-linked equations that describe the key relationships and processes within a system to simulate its behaviour. By changing the values of certain variables, researchers can see how the system responds to both external and internal changes. Because models simplify reality, their results must be used with caution. However, models in many areas have now reached such a degree of reliability that they are used routinely for operational as well as research purposes. At the present time, mathematical models are regularly used for purposes as varied as the analysis of market behaviour, the preparation of weather forecasts, and the testing of nuclear weapons. In research they are especially useful for analyzing phenomena that cannot easily be experimented with in the laboratory or in the field.

These models are particularly important in climate change research. Indeed, our present understanding of the climate system and how it is likely to respond to increasing concentrations of greenhouse gases in the atmosphere, would be impossible without the existence of what are known variously as global climate models or general circulation models – powerful computer programs that simulate the functioning of the global climate system in

[1]"First published in Spring 2000 issue (Vol.5, No.1) of 'The Climate Network' published by the Canadian Institute for Climate Studies"; reproduced here with the permission of the publisher.

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three spatial dimensions and in time. Given the scientific expertise needed to construct these models and the expensive computer resources needed to run them, it is not surprising that only a handful of countries are currently involved in advanced climate modelling.

Canada, which has been actively involved in climate modelling since the mid-1970s, is one of these countries. This work, which involves a close collaboration between scientists from Environment Canada and the universities, is now based at the Canadian Centre for Climate Modelling and Analysis (CCCma) in Victoria, B.C. Over the years, Canadian climate modellers have made important contributions to our understanding of climate processes and climate change. As we enter a new century in which climate change could become one of the greatest challenges facing humankind, their work is becoming increasingly important as a basis for public understanding and decision making. The following discussion will briefly look at the recent developments in CCCma's climate modelling capabilities, and compare these with those reported by other modelling groups.

Climate Models and the Climate System

Present concerns about climate change arise from two basic and undisputed facts. The first is that greenhouse gases, such as carbon dioxide and methane, retard the rate at which the earth loses heat to space and thus contribute to the warming of the earth's atmosphere. The second is that concentrations of these gases are increasing as a result of human activities.

This increase, which is already quite substantial and which will continue until greenhouse gas emissions are drastically reduced, will likely lead to a warming of the planet's atmosphere. We cannot be entirely certain of this, however, nor can we immediately determine how other aspects of climate might be affected, because the earth 's climate system is bewilderingly complex. It is the result not only of processes within the atmosphere itself but also of interactions involving the world's oceans, land surfaces, living things, and polar ice masses. A significant change in any one of these elements can trigger important changes in others. These in turn may cause a variety of feedback effects that further modify the original change, in some cases offsetting or moderating it, in others, enhancing it.

To determine the likely effect of a change such as an increase in greenhouse gases on the climate system, it is necessary to look at how the system as a whole responds. To do this, climate models are essential, because they integrate all the main processes that occur within the climate system and calculate all the adjustments and readjustments of its various elements as they respond to the original change.

The first models that could perform such tasks appeared in the 1970s. They simulated the workings of the earth's atmosphere in three dimensions, representing the operation of climatic processes not only at different parts of the earth's surface but also at different levels above it. Because of the limited computer power available at the time, however, their simulation of the climate system was necessarily simplistic. Oceans, which play a major role in transporting heat from one part of the globe to another, were described in a highly simplified fashion, and their interactions with the atmosphere were represented only in a very generalized way. Clouds, whose effects on the heating of the atmosphere vary with their structure, their altitude, and their coverage of the sky (as well as with the time of day), were also poorly represented and could not be changed in response to changes in other atmospheric conditions. The representation of the water cycle, which has important implications for clouds, precipitation, soil moisture, and greenhouse warming, was equally crude. In addition, early models suffered from coarse resolution. The smallest area for which these models performed their calculations took in anywhere from about 800 to more than 1000 km of latitude and longitude. As a result, the precision with which they could depict many climatic processes was limited.

By the late 1980s, however, advances in modelling techniques, understanding of climatic processes, and computer power, made possible the development of a second generation of GCMs. Although these models still used highly simplified oceans, their representation of interactions between the upper ocean and the atmosphere was much improved. In addition, spatial resolutions had been enhanced, the description of the water cycle had become more detailed, and sea ice and clouds now responded to changes in the model's climate. With these models, researchers were able to explore what they called equilibrium climate change, that is the changes in climate that would result after the climate system had stabilized in response to a given change – usually a doubling – in greenhouse gas concentrations. These models gave valuable insights into the sensitivity of the climate system to higher concentrations of greenhouse gases, but they still could not satisfactorily simulate what is known as transient climate change, that is, the behaviour of the climate system *as it is changing* rather than after it has changed. The ability to model transient change is very important, because it provides a closer approximation to how we observe the climate system from year to year and decade to decade and hence allows a more rigorous test of how well the model approximates the behaviour of the real system.

To simulate transient climate change, models needed a much better representation of ocean processes and still more computer power. By the late 1980s and early 1990s various modelling groups had begun to meet these requirements, and a much more sophisticated third generation of climate models began to emerge. Known as coupled atmospheric-ocean general circulation models (AOGCMs) or, more simply, as coupled climate models (CCMs), they include an atmospheric GCM that is fully coupled to a detailed three-dimensional model of a circulating ocean. This feature, in combination with other refinements, gives them the ability to model climate much more realistically.

At the present time, there are more than 20 such models in use or under development around the world. The Canadian Centre for Climate Modelling and Analysis completed the construction of its first coupled model, known as CGCM1, in the mid-1990s and has since run a series of transient climate change experiments. The results of these experiments are made available to the Intergovernmental Panel on Climate Change (IPCC) data distribution centre for international use in research into climate change impacts. In 1999, the U.S. National Academy of Science identified CGCM1 as one of the current leading performers in climate system simulation and recommended that its results be used in the U.S. National Climate Change Assessment.

The Canadian Coupled Climate Model

CGCM1 provides a good illustration of both the advanced features and the continuing limitations of state-of-the-art climate models at the end of the twentieth century. It is made up of four key components:

- An *atmospheric general circulation model,* with 10 vertical levels and a horizontal resolution of 3.7° of latitude and longitude (about 400 km on average). This resolution is similar to that used in most atmospheric GCMs, although some now achieve resolutions better than 300 km. Cloud cover and cloud characteristics respond interactively to other changes in the climate system.

- An *ocean general circulation model* capable of reproducing the large-scale features of the ocean circulation as well as important water properties such as temperature and salinity. Known as a modular ocean model (MOM), it was originally developed by the Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, and has been modified for use with CGCM1. It has 29 vertical layers and a horizontal resolution of about 200 km, about twice that of the atmospheric model. Its resolution is still inadequate, however, to describe fully all of the many processes that control the behaviour of the oceans.

- A *thermodynamic sea ice model* that allows ice to grow and melt in response to heat exchanges with the ocean and the atmosphere. Openings in the ice cover are represented by a relationship with the amount of ice present. This ice model was also used in earlier equilibrium experiments with CCCma's second-generation GCM.

- A simple *land surface model* that calculates runoff and soil moisture on the basis of the balance between precipitation, surface evaporation, and the water-holding capacity of the soil. The soil water-holding capacity varies with location, depending on soil type and properties. While vegetation is not included directly in the model, some of its effects are approximated by specifying different soil depths and evapotranspiration rates at different locations.

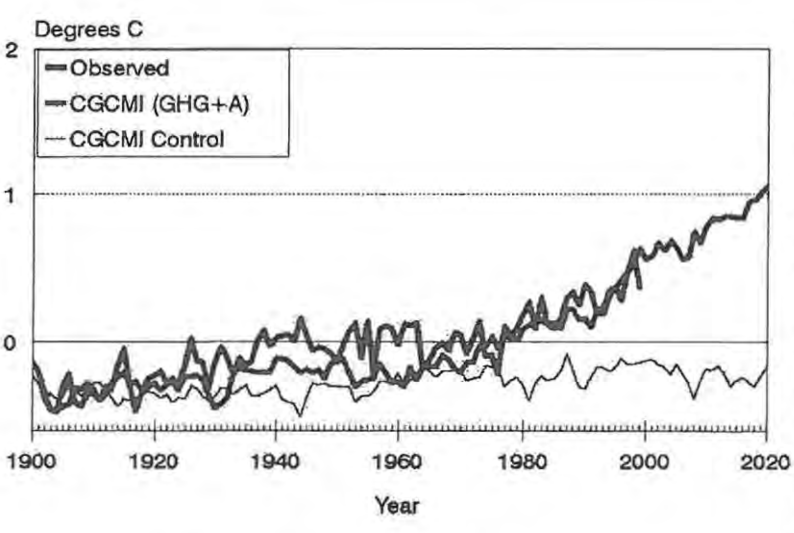
To operate the model, the ocean and atmospheric models are first individually "spun up" to an "equilibrium" condition equivalent to our present climate, and the components are then coupled together so that the atmosphere and ocean interact on a daily basis. However, errors in the modelled flow of heat and moisture between the ocean and atmosphere can cause the model to drift with time and produce unrealistic results. The problem is thought to be linked to omissions and inaccuracies in some of the models' approximations of ocean and atmospheric processes. Modelling groups have resorted to two different ways of dealing with the problem. Some assume that the drift will remain the same throughout their climate change experiments and can thus be subtracted out of the results once the rate of drift has been determined in simulations of the present climate. Other groups, including the CCCma, attempt to eliminate the drift by making adjustments to the flow of heat between the ocean and the atmosphere and the flow of fresh water into the oceans. These flux adjustments, as they are called, are then also used in any experiment that the model runs. While both methods have their advantages and disadvantages, researchers cannot rule out the possibility that either of them could introduce unforeseen errors into experimental results. Researchers at CCCma and elsewhere have given a high priority to improving ocean models so that the need for flux adjustments may be eliminated in future climate models.

Validation

The need for flux adjustments is a reminder that the results of experiments with climate models cannot automatically be accepted with complete confidence. Models are simplified approximations of a very complex reality, and their results must be interpreted with caution. That is why modelling groups put considerable effort into assessing the reliability of their models. Such assessments not only indicate where the model's performance is acceptable and where it is weak, but also help investigators interpret experimental results and refine the model's components.

The performance of a model can be validated in a variety of ways. The basic test is its ability to reproduce the principal characteristics of the present climate. Other important checks include the model's ability to simulate past climatic changes and its performance in relation to other climate models. Model comparisons are carried out by the World Climate Research Programme through the Atmospheric Model Comparison Project and the more recent Coupled Model Intercomparison Project. Results from these comparisons and other studies confirm that

CGCM1 provides a generally realistic description of the global-scale features of the world's climate system. More specifically, the model climate is quite stable, with a very slow residual drift of 0.15°C per century (about ten times smaller than the temperature changes expected during the coming decades as a result of human impacts on the climate system); mean global temperatures, sea level pressure patterns, and the atmospheric circulation are close to those observed in reality. The Southern Oscillation (which plays a role in the El Niño phenomenon), the Northern Oscillation (which is linked to periodic changes in European weather patterns), and other patterns of internal variability are also reproduced. In this respect, the model's performance is among the best of the coupled models tested under the intercomparison program. However, there are some notable discrepancies in the model's simulation of regional temperatures over land areas in winter. These are most pronounced in mountainous regions and over the Arctic Ocean. In addition, CGCM1 captures the year-to-year variability of temperatures over land quite well but underestimates it over some ocean areas, such as the tropical Pacific; global precipitation patterns also appear to be reproduced realistically, although these are more difficult to evaluate than temperature and pressure; ocean circulation, heat transport, and salinity patterns are generally within the range of observational estimates, although the use of flux adjustments appears to have been an important factor in achieving these results. Some discrepancies between simulated and observed patterns occur in polar regions, possibly because some sea-ice effects were not included in the original ocean spin-up; ice extent is well simulated in the Antarctic but underestimated in all seasons in the Arctic. Global snow cover agrees well with observations, particularly in winter, although it is overestimated in some regions (e.g., western Europe) and underestimated in others (e.g., the Mongolian Plateau). Some of these discrepancies may be due to poor observational data rather than model deficiencies.



Departure from 1951-1980 average

Simulations of Recent Climate History

CGCM1 has also been tested to see if it can realistically simulate changes in the world's climate over the past 150 years. To do so, a series of experiments was run with the model. The first of these was a control run in which greenhouse gas concentrations and other external forces of change were held constant at 1850 values. The purpose of this experiment was to provide a reference or baseline against which the results of the other experiments could be compared. A second experiment considered only greenhouse gases as a factor of change. In this experiment, increases in greenhouse gas concentrations were based on the observed concentrations of all greenhouse gases, converted to an equivalent or "effective" concentration of carbon dioxide. Finally, a set of three experiments looked at the effects of greenhouse gases and an additional factor, sulphate aerosols. These are tiny airborne particles that, like greenhouse gases, are largely byproducts of the burning of fossil fuels. Unlike greenhouse gases, however, they have a cooling effect on surface temperatures because they reflect incoming sunlight back to space. They also contribute indirectly to cooling by stimulating the formation of clouds. Sulphate aerosols differ from greenhouse gases as well in being relatively short-lived. They are thus concentrated in and downwind of the areas in which they form (mostly eastern North America and Eurasia), and their effects consequently tend to be more localized than those of greenhouse gases, which have much longer atmospheric lifetimes and are more evenly distributed around the world.

Each of the greenhouse gas plus aerosol experiments began with slightly different initial conditions in order to introduce an approximation of natural variability into the experiments. Changes in the concentration and distribution of sulphate aerosols over the 150 years of the model run were based on independent estimates compiled by aerosol experts using chemical models. Both the greenhouse gas and aerosol scenarios used in these experiments were similar to those used by other modelling groups.

The model did not take account of the indirect effects of sulphate aerosols, since these are still not adequately understood. For much the same reason, the effects of variations in the intensity of the sun, stratospheric ozone depletion, and changes in concentrations of non-sulphate aerosols were also excluded, although these have undoubtedly had some influence on climate over the past century. Various studies agree, however, that the influence of these factors on recent climate change has been distinctly secondary to that of greenhouse gases and sulphate aerosols.

When the experiments were carried out, the control run (with no change in greenhouse gases or aerosols) failed to reproduce the upward temperature trend of the past century and, in fact, showed very little change over the entire 150-year period. The simulation with greenhouse gases only, in contrast, overestimated the amount of temperature change, showing a global increase of 0.8° for the period. This simulation also failed to show the regional cooling anomalies that have been observed within the global warming trend.

The three experiments that included both greenhouse gases and aerosols, however, reproduced the climatic changes of the past 150 years with a respectable degree of realism. The modelled increase in the average global temperature of 0.6°C is consistent with the best estimates derived from climate records, although the model tended to underestimate average global temperatures in the middle of the twentieth century, perhaps because of higher solar intensity at the time and unusually low amounts of volcanic dust in the atmosphere. Both of these explanations are speculative, but neither factor was included in the simulations.

In addition, the major patterns of climate change as shown by the model were qualitatively similar to the major patterns that have been observed, with the greatest warming globally occurring in winter over central and northern areas of the Northern Hemisphere, pockets of cooling forming over parts of the oceans and, in summer, over localized areas of the continents, and the greatest warming in the Southern Hemisphere occurring over the mid-latitude oceans. The main difference between the three experiments was in the detailed geographical distribution of the projected changes. These differences reflect the different starting conditions used in the three experiments and thus confirm the model's ability to simulate the variability of the natural climate.

These results indicate that the internal processes of CGCM1 operate realistically enough to produce credible projections of global climate change when the effects of both greenhouse gases and sulphate aerosols are taken into account. In addition to validating a model's performance, however, experiments of this kind are also useful for examining the effects of different external forces on the climate system. Some modelling groups, for example, have run comparable experiments to assess the possible effects of ozone depletion on climate, while others have looked at the effects of solar variability relative to those of greenhouse gases on the climate of the past century.

New Developments in Canadian Climate Modelling Capabilities

The CGCM1 is now being used for a variety of climate change experiments, including those seeking to project how plausible future changes in atmospheric concentrations of greenhouse gases and aerosols might affect our climate. However, modellers at the CCCma are continuing to work with their collaborators in Canadian universities and elsewhere to further improve the capabilities of their model. Developments now under way or recently completed include:

i) A second version of the CGCM. Referred to as CGCM2, this improved version has now been developed and tested, and is also being used for climate change experiments. The CGCM2 continues to use the atmospheric GCMII model to simulate the atmospheric processes. However, the ocean component has been improved by replacing the simple horizontal/vertical mixing scheme with a more realistic "isopycnal" scheme. For the sea-ice component, the thermodynamic model used in CGCM1 has been augmented to include ice transport and deformation.

ii) A third version of the CGCM. In addition to further improvements to the ocean and sea-ice components, CGCM3 will include an improved atmosphere-terrestrial system from that in CGCM1 and CGCM2. For example, the atmospheric GCM II will be replaced with GCMIII, which continues to use a physical resolution of 3.7° latitude x 3.7° longitude but simulates the dynamical behaviour within the body of the atmosphere at an improved horizontal resolution of about 2.8° latitude (about 275 km) by 2.8° longitude, and at 32 layers in an atmosphere now extending to an altitude of 50 km. GCMIII will also include a new method for describing land surface flux processes and land-air interactions. Known as CLASS, this new land surface scheme is considerably more detailed than the single soil layer scheme used in GCMII. For example, it includes 3 soil layers, a snow layer where applicable, and a vegetative canopy treatment. Soil surface properties such as surface roughness and albedos are taken to be functions of the soil and vegetation types and soil moisture conditions within a given grid element of the model. The model also improves its description of: solar radiative heating processes; water vapour transport and convective behaviour within the atmosphere; the turbulent transfer of heat, moisture and momentum within the planetary boundary layer; high terrain topography; and the effect of gravity wave drag on surface winds and pressure patterns.

The ocean model used in CGCMI and II will be replaced by a new model known as NCOM1.3. Developed by the modelling group at National Center for Atmospheric Research in Boulder, Colorado, this model includes improvements in the representation of ocean physical processes, and has been coded to take advantage of more modern computer architecture.

An improved sea ice model that now includes prognostic values for ice concentrations (i.e., the fraction of each grid cell covered by ice).

iii) A Regional Climate Model: In addition to the developments under way in global climate models, CCCma is also collaborating with the Université du Québec à Montréal in the development of a Regional Climate Model (RCM) that can be 'nested' within the CGCM to provide the boundary conditions for any given region being studied, but can then used enhanced resolution, topographic detail and other improvements to generate regional climate simulations in much greater detail. The performance of the Canadian RCM (CRCM) has recently been tested using simulations over western Canada for both current and doubled CO_2 conditions. Using a spatial resolution of 45 km (almost an order of magnitude better than the GCMII model within which it was nested), the CRCM simulations showed increased spatial variability and detail in the near surface climate variables, as to be expected with the higher topographical details included, but little difference in the variability of the free atmosphere well above the surface.

The CRCM follows the improvements made in the CGCM, since it is based on almost the same physical descriptions of climate processes. Three 'three time slice' experiments with the CRCM to downscale results from CGCM1 for the present and two periods of time in the coming century are about to be completed for western Canada. Another similar set of experiments for eastern Canada is scheduled to begin soon.

Deuxième conférence internationale sur le brouillard et le captage du brouillard 15 au 20 juillet 2001 - St. John's (Terre-Neuve) (Demande de présentations)

La deuxième Conférence internationale sur le brouillard et le captage du brouillard aura lieu du 15 au 20 juillet 2001, à l'hôtel Newfoundland, à St. John's (Terre-Neuve). Elle se concentrera sur les sujets suivants : la physique, la chimie, la météorologie, la prévision et la télédétection du brouillard; le dépôt du brouillard et son interaction avec la végétation; les recherches sur la rosée; les projets de captage d'eau de brouillard dans les pays en développement; et les effets négatifs du brouillard sur les activités commerciales en mer.

Parmi les parrains de la conférence figurent l'Agence canadienne de développement international, la Société canadienne de météorologie et d'océanographie, Environnement Canada, le Centre de recherches pour le développement international et l'Organisation météorologique mondiale. On trouvera une liste à jour des parrains et exposants sur le site Web de la conférence, à l'adresse suivante:

http://www.smc-msc.ec.gc.ca/fog-conference/icffc2.html

Courts résumés avant le 1er septembre 2000

Les auteurs sont invités à présenter de courts résumés sur les sujets indiqués plus haut. Une liste complète des sujets des séances figure sur le site Web. La conférence inclura des séances spéciales sur les impacts négatifs du brouillard sur les activités (aviation, navigation, télédétection, etc.) qui se déroulent sur les océans de la planète.

Les résumés des présentations doivent être entre les mains du Professeur Hans Puxbaum au plus tard le 1er septembre 2000 à l'adresse indiquée ci-dessous. Ils doivent avoir un maximum de 300 mots, sur format 8 ½ po par 11 po, à double interligne, avec marges de 1 po. Ils seront examinés par un comité de lecture, et les auteurs seront avertis de l'acceptation au plus tard le 15 novembre 2000. Les résumés porteront un titre en caractères gras, suivi du nom de l'auteur et de son affiliation. Les sommaires plus longs destinés à être publiés dans les actes de la conférence doivent être remis au plus tard le 1er mars 2001.

Professeur Hans Puxbaum
Technical University of Vienna, Institute of Analytical Chemistry
Getreidemarkt 9-151, Vienna A-1060, Austria
Courriel : hpuxbaum@mail.zserv.tuwien.ac.at

Vous trouverez, sur le site Web à l'adresse donnée plus haut, les réponses à la plupart des questions et des exemplaires électroniques du *Fog Newsletters*. Vous pouvez aussi vous adresser par écrit à : Dr Robert Schemenauer (Président de la conférence), à la Conférence sur le brouillard et le captage du brouillard, C.P. 81541, 1057 Steeles Avenue West, Toronto, Ontario M2R 2X1, Canada; fax : (1-416)739-4211; courriel : robert.schemenauer@ec.gc.ca.

Storm Warming: Gambling with the climate of our planet
by Lydia Dotto

Book reviewed by William A. Gough
Environmental Science
University of Toronto at Scarborough

"Storm Warming: Gambling with the climate of our planet" by Lydia Dotto is a must read for all Canadians who have an interest in climate change, and especially for those who don't. Lydia Dotto is a gifted communicator who has focussed her considerable talents on the climate change issue.

The book's value lies in its clear and careful documentation and the analysis of the interplay of the science community, the media and fossil fuel industry in framing the public discourse on this issue.

Two dominant themes emerge: the importance of extreme events and the overemphasis on proof rather than the consequences of climate change.

The extreme events framework is an effective means of communicating how the apparently vague concept implied by the term 'global warming' is tangible to the public. The proof versus consequences issue underlines how the fossil fuel industry has 'waged a largely successful campaign' to place the focus of the climate change debate on a very high standard of proof analogous to the legal definition which includes 'proof beyond a reasonable doubt'. Dotto states this is an inappropriately high standard that causes unnecessary, and likely dangerous, delay. Dotto also suggests the focus should rather be placed on the consequences of climate change invoking the concept of risk familiar to all in an insurance context.

Structure

The book consists of twelve chapters, a list of acronyms and references. The book can be divided into five main sections. The first two chapters introduce the topic by stating the two prevailing themes, the importance of extreme events in the climate change discussion and the overemphasis of proof of global warming rather than the consequences of these changes. The following three chapters (3-5), describe the climate change science. This includes the climate record and climate modeling. Chapters are devoted to the examination of changes in severe weather (4) and the detection of the human influence in recent climate change (5). The next three chapters focus on the impacts of climate change on the environment, social and economic structures (6), human health (7) and psychological health (8). The last point is a novel feature of this book. Dotto reviews the lasting effects on human life of extreme events as an analogy for what we can expect and need to plan for in the future. After this, Chapters 9 to 11 move on to mitigation and adaptation issues and describes in detail the painfully long path to the Kyoto conference and its ludicrously inadequate agreement on carbon emission reduction. The final chapter returns to the main themes of her book. Dotto, from her standpoint of a journalist, insightfully examines the framing of the climate change issue by key players and the pitfalls we have fallen into using powerful analogies from the insurance industry and the legal system.

Writing Style / Audience

Dotto writes in a style that although dealing with complex issues is accessible by an interested and reasonably literate audience. She has done so without using equations and graphs which are standard fare in scientific literature. This is a plus in a book that is written for the benefit of the general public. The book follows a logical order with several main themes as an underlying structure. The book may also be appropriate for undergraduate environmental science/studies courses as well as other related fields. For courses in climate change science, the book may be helpful as an adjunct in order to provide a wider conceptual framework.

Content / Scientific Accuracy

Dotto has done her research by a series of key interviews with the leaders in the field and by actually reading and reviewing original scientific literature. The science is presented in accurate yet accessible language. The book is rich with Canadian examples. I do have a couple quibbles. Although Dotto states that the link between global warming and the El Niño phenomena is a topic of current research and still tenuous, I was led as a reader by frequent repetition of this point to feel that the link was virtually established and perhaps it was the fabled scientific reluctance that prevented a stronger statement. It is probable that many scientists do feel there is a strong link and that I am expressing a minority position. Although I acknowledge the apparent odd behaviour in the last two to three decades of the El Niño phenomena, this odd behaviour is set in a conceptual framework that accepts the more or less regular periodicity of El Niño. Because of the lack of detailed knowledge of this phenomena prior to the 1960's it is difficult to state that the recent behaviour is anomalous. Every reviewer with his own area of research has a bias, as I do. Although it is more likely a reflection of the available literature than Dotto's skill as a synthesizer of the climate change issue, I was a little disappointed that the climate change impact on the Hudson Bay region did not receive more notice.

This Bay has at present a complete cryogenic cycle which has a profound impact on the local climate, causing the southern extension of permafrost and allowing for a local population of polar bears. These bears are the foundation of Churchill, Manitoba's eco-tourism and their plight has been covered recently in the media. This area is particularly sensitive to climate change and profound changes are anticipated once the seasonal ice disappears which some simulations suggest will occur within the next fifty years. In John Houghton's "Global Warming: the complete briefing", a chapter casting the global warming in a religious framework was a most welcome perspective. Most writers, perhaps reflecting the environmental movement as a whole, have avoided this standpoint. Houghton invoked the concept of stewardship from various religious traditions as a moral framework to motivate change. Other religious paradigms take a variety of different views on the natural world and this has important implications on human activity. This is an area that is well worth exploring. This is not covered in Dotto's book but perhaps it is another book in itself.

Ocean-Atmosphere Interaction and Climate Modelling

by Boris.A.Kagan
P.P.Shirshov Institute of Oceanology
St-Petersburg
Cambridge
Atmospheric and Space Science Series,1995

Book reviewed by André April
Trenton Weather Services Centre

This book is written by an Oceanologist who emphasizes the leading role of the ocean in the long-period variability of the ocean-atmosphere system. The book emphasizes the current representations of the climatic system as a totality of the interacting atmosphere, ocean, lithosphere, cryosphere and biosphere and introduces the reader to new methods and results of theoretical and experimental research giving the reader an opportunity to understand the extraordinary complexity of these interactive systems which should stimulate the reader to independent thinking.

In the first chapter the author presents the methods of experimental research. He takes the viewpoint that the predictability of numerical models is limiting and there are non-unique solutions to climate-earth system governing the circulation of deep water. Also, the author discusses the categories of the climatic system oscillations according to Monin (1969) and the existence of feedback mechanisms between different internal parameters of the climatic system. The chapter dicusses the possibilities of using satellites to research the characterictics of the ocean-atmosphere system given the accurancy of the measurements.

Chapter two relates the present state of the climatic system with the mass budget and heat, moisture, energy, momentum and carbon budgets.The carbon budget includes the carbon contents of ocean, the carbon sources and sink, times of renewal and the carbon exchange of the ocean-atmosphere interface. The budgets take into account the atmosphere, ocean, ice cover and land. The data is extracted from Peixoto and Oort (1989).

Chapter three entitled "Small Scale Ocean Atmosphere Interaction" begins with the subject of the surface atmospheric layer and the estimate of the layer height of the vertical momentum flux, heat flux and humidity flux. After that, the author presents the derivation of the vertical distribution of the mean velocity of the wind over an immovable smooth or rough surface. With respect to the hydrodynamic properties of the sea surface Kagan reviews five of the most popular methods used to estimate the roughness parameter of the sea surface including the method of Donelan (1982). He presents also the wind wave devopment theory accompanied by momentum and energy transfer to waves in the limiting situation where wave breakdown and drift current formation do not occur. From the Russian Belinov's research the author presents the transformation of the thermal regime of the surface atmospheric layer in the presence of wind-wave interaction and three methods for estimating the surface fluxes including one method for the CO_2 flux. It's a well documented chapter referencing original Russian researches.

Chapter four discusses the Mesoscale Ocean-Atmosphere Interaction. The author begins by studying the condition of a quasi-stationary Planetary Boundary Layer (PBL) for estimating the level of the free atmosphere above the surface. The author continues with a discussion of the problem of closure of the equations for the PBL. The most important part here is the treatment of the theoretical of the ocean and atmosphere system and linkages of the PBL-Free atmosphere and PBL-Deep ocean with and without an eddy viscosity coefficient.

Chapter five begins with the basic ideas concerning the principles of the construction of deterministic models which have played an important role in the climate theory. The most important model developed is the 0.5 dimensional thermodynamic box suggested by Kagan (1990) that simulates the seasonal variability of the climatic system of northern hemisphere. The next reviews the three dimensional models of the ocean-atmosphere system. The models include the GFDL model from the laboratory of Geophysical Fluid Dynamics; IOAS model from the Russian Academy of Sciences; CCSBAS model from Computer Centre of Siberian Branch of Russian Academy (Marchuk (1984)); NCAR model from the National Center for Atmospheric Research; OSU model from Oregon State University; UKMO model from the U.K. Meteorological Office and the MPI model Max-Planck Institut complete the discussion about coupled ocean-atmosphere GCM's.

Chapter six presents the results of numerical experiments on the equilibrium reponse of the ocean-atmosphere system to external forcing. The results of numerical experiments suggest possible limiting changes to climatic systems. The author incorporates the ideas of changes in the ocean land ratio, the concentration of atmospheric CO_2, the land surface albedo, the soil content, the vegetative cover and the impact of cloudiness, insolation and heat transport in the ocean. Additionally the author examines two extreme situations; the destruction of forest tracts and the total destruction of the vegetative cover.

In conclusion, it is a well documented book with all the mathematical details and includes original Russian viewpoints. More than three hundred references have been cited in this book.

New Publication

Uncertainties in Greenhouse Gas-Induced Climate Change[1] by Madhav L Khandekar[2]

The purpose of this report is to assess the uncertainty associated with the science of climate change and global warming and determine the present state of our knowledge. The study examines several issues in the light of a large number of publications reported in recent literature and determines the present status and uncertainties associated with these issues.

Important findings of the report are:

1. The annual global mean surface temperature warmed by 0.57°C over the period 1861-1997 and by 0.62°C over 1901-1997. For the recent 20-year period (1978-1997), the mean surface temperature increase is estimated to be about 0.32°C or about 0.16°C per decade. The spatial distribution of the temperature change also reveals a cooling of between 0.5° to 1.0°C during the last thirty years over the northwest Atlantic, parts of eastern Canada and the southeastern United States, and a sizeable area over central/eastern Europe and western Russia.

2. The mean temperature trend of the troposphere as determined by the satellite-based radiometric data over the last 19 years(1979-1997) is now estimated to be about 0.1°C per decade. Recent studies attempt to explain the difference in mean temperature trend between surface and troposphere in terms of cooling of the troposphere due to stratospheric ozone depletion and warming of the surface due to urbanization and land-use change.

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3. The increase in mean surface temperature of the Earth is attributable to a number of factors as per several recent studies. The differential changes in daily maximum and minimum temperatures, resulting in a narrowing of the diurnal temperature range (DTR) appears to provide at least a partial explanation for the mean temperature increase. The mean maximum temperature has increased over most areas of the Earth with the notable exception of eastern Canada, the southern United States, portions of eastern Europe, southern China and parts of southern South America. The mean minimum temperature has increased almost everywhere, except over eastern Canada and small areas of eastern Europe, the Middle East and at most locations over India. The daily minimum temperature has been increasing at a faster rate or decreasing at a slower rate than the daily maximum; consequently, the DTR has decreased in most areas thus increasing the mean temperature by up to 0.3°C or more.

4. Slowly varying large-scale atmospheric oscillations like the SO (Southern Oscillation) and the NAO(North Atlantic Oscillation) which were first identified by Sir Gilbert Walker in the 1920s and the more recently identified oscillation, namely the Arctic Oscillation (AO), can explain part of the observed increase in the mean surface temperature of the Earth. The SO and the associated El Niño phenomena have contributed towards positive surface temperature anomalies over western Canada and northwestern United States, while the strong positive phase of the NAO since 1980 has contributed to the positive temperature anomalies over western Europe and parts of Eurasia.

5. Changing solar radiation since 1900 and its forcing on the Earth's climate may have contributed to about half of the observed warming of the Earth's surface during the last one hundred years.

6. No studies reported so far have directly and unequivocally linked increased concentration of greenhouse gases to the recent increase of the mean surface temperature of the Earth. The most probable cause of the mean surface temperature increase is now considered to be a combination of internally and externally forced natural variability and anthropogenic sources.

7. The radiative forcing by anthropogenic aerosols (sulfate in particular) is now identified as an important perturbation which can significantly influence the present and the future climate. The direct and indirect (cloud-mediated) radiative forcing effects due to sulfate aerosols are presently assessed to be about -4.8 and -4.0 Wm^{-2} over the southeastern USA. A few recent studies have identified a small cooling trend in the surface temperature records of the southeastern USA.

8. An analysis of precipitation data (1910-1995) over the conterminous United States shows an increasing trend in percent contribution of the upper ten percentile of daily precipitation events to the total annual precipitation, thus suggesting an intensification of the hydrologic cycle as per IPCC 1996 conclusion. However, a similar analysis for Canada shows a decreasing trend from 1910 through 1995 for stations located in southern Canada; for stations located north of 55^0N in Canada, there is a ten percent increase in precipitation based on a shorter (1940-1995) data set. Over the Canadian prairies, there is no increase in heavy precipitation events. Elsewhere, an analysis of summer (June-September) monsoon rainfall over China and India does not show any increasing trend in extreme precipitation events. Over Indonesia/Malaysia, available data do not reveal any increasing trend in precipitation. For the Australian continent, the percentage area of the continent experiencing extreme wet conditions appears to have increased slightly while the area of extreme dryness has reduced slightly since 1910; however, this variability in extreme climate appears to be governed primarily by the frequency of El Niño and La Niña events. On a global or continental scale, there is no evidence of intensification of the hydrologic cycle in recent years.

9. There is no increasing trend in the total number of hurricanes occurring in the North Atlantic; nor is there any increasing trend in the intensity of Atlantic hurricanes as measured by the wind speed. The central Pacific region appears to show an increase in the total number of hurricanes while the Australian region shows a distinct reduction in recent years in the total number of tropical cyclones. The interannual variation of hurricanes in the Atlantic as well as in the Pacific is found to be primarily governed by the phase of the ENSO (El Niño/Southern Oscillation) phenomena.

10. Recent studies using sea-level data sets over northwest Europe indicate a small weakening of the storm climate in the southern North Sea, while for the northern North Sea region, a small (but insignificant) increasing trend in the storm climate is indicated.

11. There is no evidence of an increased frequency of El Niño (warm phase of SO) events in the equatorial central and eastern Pacific. The present La Niña (or the cold phase) of SO which began in June 1998 is expected to continue till March 2000 as per recent analysis.

12. The predicted impact of global warming in terms of increased frequency of extreme weather events (e.g. extreme precipitation, extreme drought, increased number of tropical and extra-tropical storms, etc.) is not borne out by recent observational studies at this point in time.

Priority Areas of Research:

Several areas of research relating modelling and observational aspects of the science of global warming and climate change can be identified. From an observational perspective, there are still large gaps in our observations of the atmosphere-ocean system. The Arctic and the Antarctic are probably the two best locations to exemplify the observational gaps and the uncertainty in appropriately defining the atmosphere-ocean system in these regions (see Curry et al., 1996). Other regions with observational gaps are land areas of tropical Africa and South America, tropical southeast Asia with particular reference to the maritime continent of Indonesia and vast areas of open ocean in the Southern Hemisphere. From a modelling perspective, several uncertainties exist in adequate simulation of ENSO phenomena and in suitable coupling of atmosphere and ocean components of the climate models. Taking into account all these uncertainties, the following priority areas of research are identified.

A. A cooperative effort is required to build a data base and to construct temperature and precipitation trends on a regional, national, continental and on a global basis. A detailed analysis of these trends would be necessary to identify and remove any local and/or regional bias. An excellent example is a recent study (Skinner and Majorowicz,1999) on regional climatic warming and associated land-cover changes in north-west North America. The study finds an interesting correlation between the surface air temperature increase and the ground surface temperature (as determined from well data) and further assesses the impact of land-cover changes on these temperatures. It would be useful to make such detailed analysis of temperature and precipitation trends in regions where local and regional influences are known to exist.

B. Improving the observational network especially in the high latitude regions (Arctic and Antarctic) and over tropical oceans and land areas. The recent program called the GCOS (Global Climate Observing System) which has been launched through the WMO (World Meteorological Organization) should help define the climate and its variability in a more precise manner so that future projections of climate change can be detected more precisely and its attribution to natural and/or anthropogenic forcing can be more accurately determined. In a comprehensive paper Barry (1995) emphasizes the need for an observing system and data sets related to the cryosphere in Canada. Barry further describes the cryospheric data and its geographical variety and extent in Canada as providing a valuable window on the stability of climate in the Arctic and in middle latitudes. In a recent study on climate extremes, Karl and Easterling (1999) have emphasized the need for an improved data set to establish a link between climate extremes and GHG-induced climate change. As Karl and Easterling have succinctly summarized, *"There are a number of impediments preventing us from more effectively understanding the linkages between changes in climate extremes and natural hazards to anthropogenically-induced climate change. Certainly model deficiencies are high on the list, but just as important is our lack of reliable long-term climatic data. Time and time again, we find that our observing systems and data sets often have large systematic biases of uncertain magnitude casting doubt on our ability to detect multi-decadal changes. This is why efforts like the GCOS are so critical "*.

C. While acknowledging significant progress in climate modelling, it must be realized that most climate models have grid spacing which is too coarse for adequately representing mesoscale oceanic and atmospheric features. There is a definite need to develop finer resolution models and develop suitable parameterization techniques to represent mesoscale features in the models. An associated problem will be to develop revised calculations of radiative forcing from natural and anthropogenic aerosols and their interaction with mesoscale features.

D. The ENSO phenomena is now identified as the strongest climatic signal in the coupled atmosphere-ocean system outside of the diurnal cycle. It is imperative that climate models must be improved to realistically simulate the ENSO cycle and the associated global weather anomalies. Climate models with inadequate simulation of the ENSO cycle are unlikely to produce realistic response to perturbation from increasing GHG concentration. An associated aspect is the inadequate simulation of summer Monsoon from Africa to Indonesia (Gadgil and Sajnani, 1998). The ENSO-Monsoon connection has been amply demonstrated in several recent studies (e.g., Webster and Yang, 1992; Khandekar, 1996). The summer Monsoon and ENSO are two important features of the atmosphere-ocean system which must be adequately simulated in future climate models.

There are some issues relating future scenarios which have not been discussed so far. The IPCC 1996 report developed a number of scenarios based on a wide range of assumptions regarding future economic development, population growth and energy usage. From these scenarios, projected future atmospheric concentrations of GHG are calculated and are then used in climate models to develop projections of future climate. A recent paper by Gray (1998) makes a critical analysis of these scenarios and concludes that the IPCC scenarios exaggerate the extent of one or more factors determining future emissions. The paper further shows that the inaccuracies involved in calculating future atmospheric concentrations of GHG are so great as to render the calculations highly unreliable. This study once again points towards the uncertainty involved in projecting the future evolution of atmospheric chemistry and its possible impact on future climate.

Finally, a few research areas that can be identified on a regional (provincial) scale as described in the terms of reference of this project:

1. A thorough analysis of precipitation and temperature trends over western Canada with particular reference to the province of Alberta and determine spatial and temporal variability of these trends.

2. Collect and carefully analyze data on extreme events (e.g. blizzards, heat waves, intense precipitation and associated floods, thunderstorms and tornadoes) over western Canada, and determine if any trends exist.

3. Collect data on local and regional land-use and land-cover changes and assess their influence on precipitation and temperature in particular.

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A Disaster Loss Reduction Program for Canada

Presented to: The Standing Committee on Finance-House of Commons, Ottawa
3 May, 2000

James P. Bruce[1]

Economic losses and human suffering from natural disasters have increased markedly in Canada since the early 1980s. While insurance losses have increased substantially, the largest increases and shares of the costs have been borne by governments, federal and provincial, and by individuals. The losses have been almost exclusively weather and climate related – storms, floods and drought. These trends are very likely to continue because:

1. populations and infrastructure at risk continue to increase;

2. many of the measures to limit or protect development in hazardous zones, e.g. flood plains, are falling into disuse, due to government cut backs and policies at both senior or federal and provincial levels;

3. human-induced global climate change is projected to increase the frequency and severity of extreme weather events and there are some signs that this is already occurring.

This experience of increasing climate-related disaster losses is not confined to Canada. Globally, from the early 1960s to early 1990s, the number of earthquake losses causing more than 1% of GDP damage to countries affected has doubled. However, over the same period, the number of large climate-related losses by the same criterion have gone up 4 to 6 times.

Climate projections for this century, assuming a continued increase of greenhouse gas concentrations in the atmosphere, particularly carbon dioxide, are:

1. more frequent short-period heavy rainfalls causing flash flooding;

2. fewer but more severe winter snow and ice storms;

3. more frequent drought in mid-continental areas from Lake Superior to interior B.C.;

4. sea level rises accompanying global warming causing more frequent flooding and erosion on east and west coasts.

Observed evidence confirms that these trends are already occurring in Canada.

The recent history is similar in most countries. All three factors listed in para 2 are expected to continue increasing, that is: exposure of more infrastructure to risks, community vulnerability with unrestricted development of hazardous areas, and the frequency and severity of climate-related hazards.

At the same time, disaster mitigation through better building design, land use planning, warning and preparedness systems and other measures have clearly demonstrated a capability of saving lives and reducing economic losses. As economic and human losses mount, and the value of disaster mitigation efforts are recognized, revised policies and programs have been launched nationally and internationally. Responding after the disaster has occurred is no longer considered to be an adequate policy position. Rather a mitigation or disaster loss reduction program and policy has been adopted in many countries to reduce the costs of response and compensation, and alleviate human suffering.

For example, in the U.S.A. the Federal Environmental Management Agency now devotes 15% of their very large disaster response payouts to loss prevention measures. These include:

a) moving people from flood plains and vulnerable coastal areas; and

b) flood proofing measures.

A similar policy is being adopted by the World Bank. At the same time many countries are re-examining building design codes and their enforcement, lending policies in hazard zones and drainage design to minimize losses. Warning and preparedness systems are being strengthened to save lives and moveable property. Drought management plans have reduced losses and hardship in many countries, (e.g. Brazil and India).

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Note from the Editor

In the June issue of the CMOS Bulletin SCMO (Vol.28, No.3, page 82) we presented *"The remarks to the Senate Committee on National Finance concerning Canada's Emergency and Disaster Preparedness"* submitted by W. Pugsley. We are now pleased to present the report submitted by J.P. Bruce.

Internationally, the UN's International Decade for Natural Disaster Reduction (the 90s), now the International Strategy for Disaster Reduction urges all countries to undertake comprehensive assessments of their risks, minimize such risks in development planning through a wide range of measures, and avail themselves of the best warning and preparedness systems.

In Canada, in spite of recent disaster experience, we have been moving backwards. For example, the federal-provincial cost-shared flood damage reduction program designed in the 1970s to minimize development in flood plains, has fallen into neglect. Environment Canada no longer funds completion or up-dating of flood plain maps and many provinces have weakened efforts to limit development in hazard lands.

A strong multi-pronged program of disaster loss prevention is clearly needed in Canada. Because of its accepted responsibility for disaster loss payouts after extreme events, and drought relief contributions it is only good business sense to take steps to reduce federal liability. A similar rationale applies to the provinces.

At the federal level, a number of agencies and Departments are involved and this may be why a comprehensive disaster loss reduction program has not been undertaken. Among the agencies who are, or should be, concerned, are:

- Environment Canada, particularly Meteorological Service (storms, floods, droughts) and Water elements;
- Natural Resources Canada (earthquakes, volcanoes, water, forest fires);
- National Research Council (building codes);
- Department of Fisheries and Oceans (tsunamis, storm surges);
- Agriculture Agri-Food Canada, (droughts, floods);
- Indian and Northern Affairs, (northern disasters);
- Heritage Canada, (disasters in Parks, e.g. avalanches, fires);
- CIDA/DFAIT, (humanitarian assistance, disaster mitigation in developing countries).

At the same time, it is Emergency Preparedness Canada of DND, which administers disaster loss compensation funds and plans response actions.

In short, the federal liability is rapidly increasing. Disaster mitigation efforts could reduce such liability, but responsibilities are spread through a number of agencies.

Thus it seems highly appropriate that the House of Commons, Finance Committee with crosscutting responsibilities, should be addressing this issue. For wise fiscal management and to relieve suffering of Canadians, I would urge you to recommend a comprehensive disaster loss reduction program for Canada.

The 1999 Prizes and Awards

Report from the CMOS Prizes and Awards Committee

President's Prize

The President's Prize was given to two individuals this year: Professor Alex Hay of the Department of Oceanography, Dalhousie University, Halifax and Dr. William Hsieh of the Department of Earth and Ocean Sciences, University of British Columbia, Vancouver.

Dr. Alex Hay is cited for his internationally acclaimed research on ocean acoustics and megaripple formation in the nearshore coastal zone, and specifically for his co-authored publication with A.J. Bowen entitled "Longshore migration of lunate megaripples during DUCK94" (*Journal of Geophysical Research*, in press). His research combines the fundamentals of ocean physics with the development and application of new acoustical instrumentation. Dr. Hay continues to make major contributions to our understanding of acoustic processes in the ocean and has played a key role in international field programs such as those conducted at well-known experimental sites off Duck, North Carolina and southern New Jersey. Dr. Hay has provided new insight into the physics of the benthic boundary layer, the shape and height of bedforms, profiles of suspended sediment concentration and 3-dimensional turbulence. He is a leader in physical oceanography in Canada and an internationally recognized expert in the challenging field of ocean acoustics.

Dr. William Hsieh is cited for his outstanding contribution to global climate research through the development and application of Neural Network techniques for the analysis and forecasting of climate variability, and specifically for his paper "Forecasting ENSO events: A Neural Network-Extended EOF approach" (*Journal of Climate*, 11, 1998). Dr. Hsieh has demonstrated that historical time series of El Niño-related events can be closely reproduced using a Neural Network approach with a relatively small number of parameters. He also has shown that the so-called "hidden layer" variables in this widely-used technique can be interpreted in terms of coefficients of a nonlinear generalization of the traditional linear empirical orthogonal functions. Dr. Hsieh's approach has produced impressive forecasts of pending ENSO events in the Pacific Ocean and he was the first in the world to predict the development of La Niña conditions in 1999/2000. Dr. Hsieh has established himself as a leading forecaster of short-term climate variability, and his results are now eagerly anticipated by the international ENSO prediction community.

Dr. Andrew Thomson Prize in Applied Meteorology

Professor Edward P. Lozowski of the Department of Earth and Atmospheric Sciences, University of Alberta, was the unanimous choice for the Andrew Thomson Prize in Applied Meteorology. Dr. Lozowski is cited for his extensive research on ice accretion with application to hail, aircraft icing, transmission line icing, and marine icing. Professor Lozowski is an exceptionally talented scientist who has made numerous high quality contributions to the area of applied meteorology so critically important to Canada and the world engineering community. The Prize is for his cumulative research and his many "firsts" in operational and applied meteorology.

Tertia M.C. Hughes Memorial Prize

The Tertia Hughes Memorial Prize was awarded to Dr. Zhaomin Wang of McGill University for his 1999 Ph.D. thesis "A simple coupled atmosphere-ocean-sea ice-land surface-ice sheet model for climate and paleoclimate studies" and to Dr. Brian May of Dalhousie University for his 1999 Ph.D. thesis on "Double-diffusive interleaving in baroclinic ocean fronts".

Citations

Drs. H. Janzen, R. Desjardins, R. Asselin and B. Grace of Agriculture and Agri-Food Canada received a Citation for their publication "Health of our Air". This publication has provided concise and comprehensive insight into Canadian agriculture in relation to global change. By addressing the role and impact of farming practices, emissions of various gases by individual sectors, and options for management, they have achieved a milestone contribution to the debate on climate change and its impact on Canada.

Second International Conference on Fog and Fog Collection
July 15-20, 2001 St. John's, Newfoundland
(Call For Papers)

The Second International Conference on Fog and Fog Collection will be held at the Hotel Newfoundland, in St. John's, Newfoundland, Canada, 15-20 July 2001. The Conference will focus on: the physics, chemistry, meteorology, forecasting, and remote sensing of fog; fog deposition and the interaction of fog with vegetation; dew research; fog collection projects in developing countries; and the negative effects of fog on commercial offshore activities. Conference sponsors include: Canadian International Development Agency, Canadian Meteorological and Oceanographic Society, Environment Canada, International Development Research Centre and the World Meteorological Organization. A current list of sponsors and Exhibitors can be found on the conference web site:

http://www.tor.ec.gc.ca/fog-conference/icffc2.html

Short Abstracts by September 1, 2000

Authors are invited to submit short abstracts on the topics noted above. A complete list of session topics can be found on the web site. The conference will include special sessions on the negative impacts of fog on offshore activities (aviation, shipping, remote sensing, etc.) in the oceans of the world.

Short abstracts of papers must be received by Professor Hans Puxbaum by 1 September 2000 at the address given below. They should be a maximum of 300 words, on 8 ½" x 11" paper, double spaced, with 1" margins. The short abstracts will be peer reviewed and the authors notified of acceptance by 15 November 2000. The abstracts should have a title in bold, followed by the author's name and affiliation. Extended abstracts for publication in the Conference Proceedings are due 1 March 2001. Professor Hans Puxbaum, Technical University of Vienna, Institute of Analytical Chemistry, Getreidemarkt 9-151, Vienna A-1060, Austria. Email: hpuxbaum@mail.zserv.tuwien.ac.at

Please see the web site address given above for answers to most queries and for electronic copies of the *Fog Newsletters*. You may also write to: Dr. Robert Schemenauer (Conference Chair) at the Conference on Fog and Fog Collection, P.O. Box 81541, 1057 Steeles Avenue West, Toronto, Ontario M2R 2X1, Canada; fax (1-416)739-4211, e-mail: robert.schemenauer@ec.gc.ca.

Patterson Medals Awarded

Ottawa – June 13, 2000 – The MSC 1999 Patterson Distinguished Service Medals for outstanding service to meteorology in Canada were awarded to Dr. James R. Drummond, Professor in the Physics Department at the University of Toronto, and Dr. Peter H. Schuepp, Professor in the Natural Resource Sciences Department at McGill University. Dr. Gordon McBean, Assistant Deputy Minister of the Meteorological Service of Canada (MSC), presented the medals at the annual Canadian Meteorological and Oceanographic Society (CMOS) Congress in Victoria, British Columbia, on May 30, 2000.

Dr. Drummond has demonstrated his commitment to meteorology by contributing to the development of a close collaborative relationship between the Canadian atmospheric sciences community and the Canadian Space Agency. The Measurement of Pollution in the Troposphere (MOPITT) remote sensing system, which he developed, represents a cornerstone of the international effort. Dr. Drummond has the ability to balance both his dedication to higher education - through his teaching position at the University of Toronto - and his generous contribution of time in the service of Canadian meteorological organizations.

Dr. Schuepp's contribution to meteorology is evident through his outstanding talents as a teacher, mentor and supervisor of graduate students. He has also made significant contributions to the Canadian meteorological community as an executive member of McGill's Centre for Climate and Global Change Research, as an editorial board member of the publication Boundary Layer Meteorology, and as a leader of many Canadian and international field programs.

The Patterson Distinguished Service Medal, presented since 1954, is considered the pre-eminent award recognizing outstanding work in meteorology by residents of Canada. This prestigious award is named in honor of Dr. John Patterson, a distinguished meteorologist who was Director and Controller of the Meteorological Service of Canada from 1929 to 1946, a crucial period in the development of Canada's weather service.

Remise des Médailles Patterson

Ottawa – Le 13 juin 2000 – Les Médailles du SMC pour services distingués Patterson de 1999, remises en reconnaissance de services éminents en météorologie au Canada, ont été décernées à M. James R. Drummond, professeur au département de physique de l'Université de Toronto et à M. Peter H. Schuepp, professeur au département des ressources naturelles de l'Université McGill. C'est M.Gordon McBean, le sous-ministre adjoint du Service météorologique du Canada (SMC), qui leur a remis les médailles lors du Congrès annuel de la Société canadienne de météorologie et d'océanographie (SCMO) qui s'est tenu à Victoria, en Colombie-Britannique, le 30 mai 2000.

M. Drummond a fait la preuve de son engagement à la météorologie en participant à l'établissement d'une collaboration étroite entre la communauté canadienne des sciences atmosphériques et l'Agence spatiale canadienne. Le système de télédétection MOPITT, qu'il a mis au point pour mesurer la pollution dans la troposphère, constitue la pierre angulaire de l'effort international. M. Drummond, tout en se consacrant à l'enseignement supérieur, enseigne à l'Université de Toronto et offre généreusement de son temps aux organismes météorologiques canadiens.

La contribution de M. Schuepp à la météorologie est évidente et ses talents exceptionnels d'enseignant, de mentor et de superviseur d'étudiants diplômés en témoignent. Il a également apporté une contribution importante à la communauté météorologique canadienne en faisant partie de l'exécutif du Centre de recherche sur le climat et le changement planétaire de McGill, du comité de rédaction de la publication *Boundary Layer Meteorology*, et en assumant la responsabilité de nombreux programmes de terrain aux paliers national et international.

La Médaille de services distingués Patterson est décernée depuis 1954 et est considérée comme le prix qui reconnaît l'excellence du travail en météorologie des résidents canadiens. Ce prix prestigieux doit son nom à John Patterson, météorologue réputé qui fut directeur et contrôleur du Service météorologique du Canada de 1929 à 1946, période cruciale pour le développement du service météorologique du Canada.

Système All Channel Alert "ACA"

Pelmorex Communications Inc., propriétaire et exploitant des chaînes The Weather Network et MétéoMedia, a mis au point une technologie, le système All Channel Alert (ACA), qui permet d'alerter les téléspectateurs de chaînes distribuées par câble lors d'urgences météorologiques ou autres dans leur région. Cette technologie peut intercepter TOUTES les chaînes distribuées par une compagnie de cablodistribution dans la région touchée par l'urgence et afficher à l'écran de télévision un message d'avertissement afin d'aviser les téléspectateurs de l'urgence imminente, quelle que soit la chaîne de télévision écoutée. Ce système a été testé dans plusieurs villes à travers le Canada conjointement avec Environnement Canada. Pelmorex a présenté une demande au Conseil de la radiodiffusion et des télécommunications (CRTC) en vue de modifier sa licence de diffusion pour offrir ce service.

Pour commencer, le système ACA diffusera des alertes météorologiques, telles qu'elles ont été définies par le programme général d'avertissement météorologique d'Environnement Canada. Éventuellement, d'autres agences gouvernementales fédérales autorisées ou autorités applicables au niveau provincial ou municipal, auront accès au système ACA pour diffuser d'autres messages d'urgence. Ce type de système possède de nombreux avantages; il est rapide, efficace et permet de rejoindre un grand nombre de personnes en quelques secondes; il livre un message non altéré au nom d'agences gouvernementales autorisées et, donc, ne fait pas l'objet d'interprétation; il est disponible dans les deux langues officielles; il est transmis à l'ensemble du pays et cible son message aux téléspectateurs de la région affectée par l'alerte.

Lors de sa dernière réunion (le 11 mai 2000), l'Éxécutif de la SCMO a consenti, en principe, à appuyer le demande de Pelmorex. Le système par câblodistribution règle, en partie du moins, les inquiétudes transmises par la SCMO au CRTC que le Canada n'est doté d'aucun moyen pour assurer que les médias diffusent en temps opportun les avertissements météorologiques émis par Environnement Canada. La SCMO fera parvenir une lettre au CRTC lorsque celui-ci fera appel à l'avis public.

Note from the Editor: The English version of this document appeared in the June issue of the *CMOS Bulletin SCMO*, Vol.28 No.3, pp.93-94.

Note to the Editor

According to a short note on page 279 of EOS for this year, June 20th edition, Lawrence Mysak has been elected a Foreign member of the Earth and Cosmic Sciences Section of the Academia Europæa, only the third Canadian to receive this honour.

Howard Freeland

CMOS is proud to have Lawrence as a Member and Fellow. The Society wishes to extend its sincere congratulations to Lawrence on this honour.

Peter Taylor, President

Climate Change Workshop

The Climate Change Workshop 2000, "Community Forecast", is scheduled for 12-13 October 2000 in Miramichi, NB. The Workshop is designed to inform, network and mobilize Atlantic Canadian communities and non-government agencies on climate change issues that have, or will have, impact on the lives of people in the region. For information, email the Miramichi River Environmental Assessment Committee at mreac@nbnet.nb.ca

Gulf of Maine International Ocean Wilderness

Senior marine scientists from Canada and the USA, boosted by leading public lands and conservation groups, formally called on Prime Minister Jean Chrétien and President Bill Clinton to jointly designate a 32 km-wide and 300 km-long band of seafloor along the Canada/US offshore border as the Gulf of Maine International Ocean Wilderness. For details, access http://www.atlantisforce.org

Canadian Hurricane Centre

Hurricane season has arrived. Access the Canadian Hurricane Centre website at:

http://www.ns.ec.gc.ca/weather/hurricane/index_e.html

to obtain information on hurricanes, including the latest radar and satellite images, public weather warnings, bulletins, hurricane tracks and general information about hurricanes, etc.

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