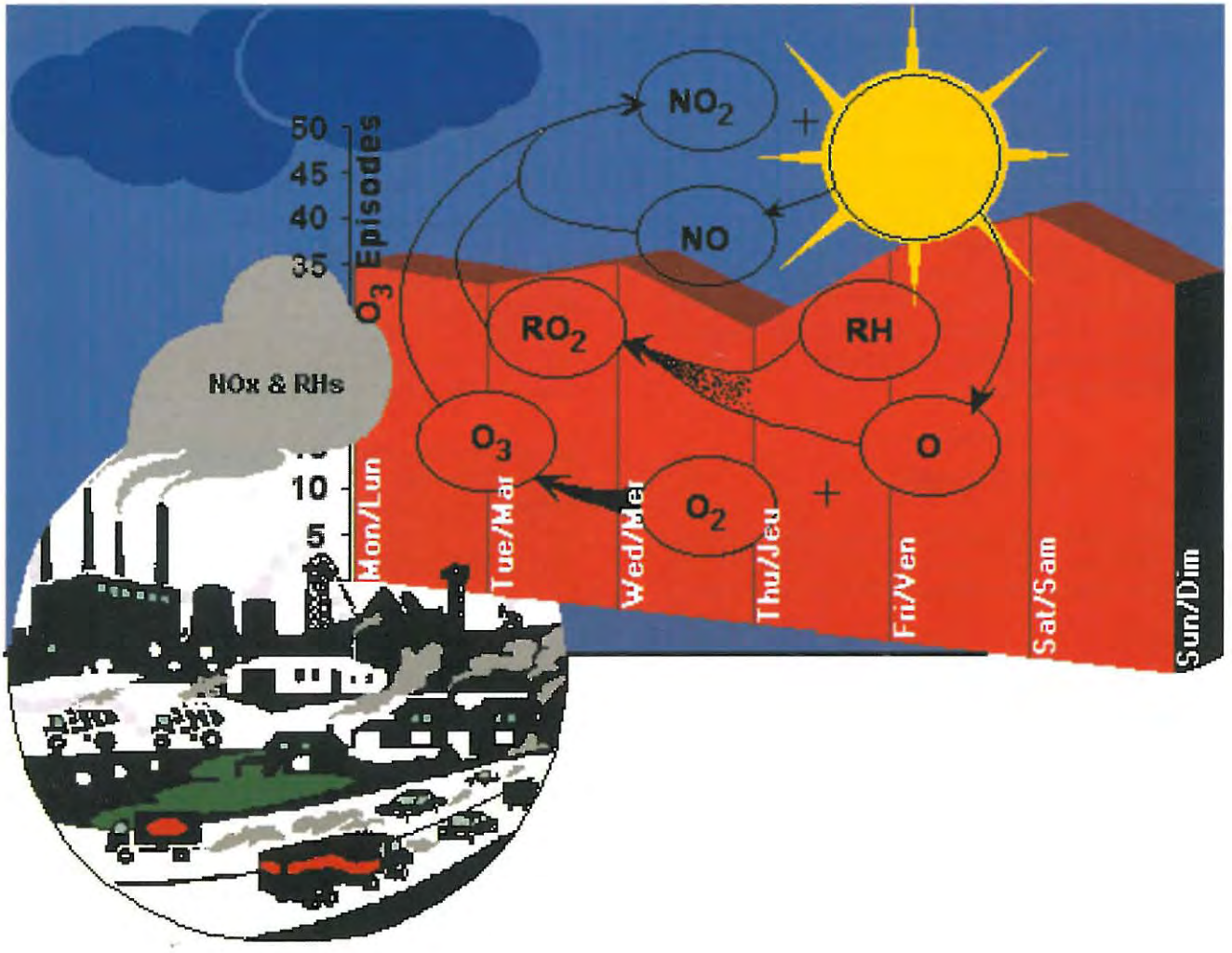
ISSN 1195-8898

CMOS BULLETIN SCMO

Canadian Meteorological and Oceanographic Society

La Société canadienne de météorologie et d'océanographie

February / février 1999 Vol. 27 No. 1



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

Editor / Rédacteur: Paul-André Bolduc
Marine Environmental Data Service
Department of Fisheries and Oceans
12082 - 200 Kent Street
Ottawa, Ontario, K1A 0E6, Canada
☎ (613) 990-0231; Fax (613) 993-4658
E-Mail: BOLDUC@MEDS-SDMM.DFO-MPO.GC.CA
Canadian Publications Product Sales Agreement #0869228
Envois de publications canadiennes Numéro de convention #0869228

Cover page: Nitrogen oxides (NOx) and hydrocarbons (Rhs) are emitted by vehicles and industrial sources (illustrated in the bottom left bubble), which, under the effect of the sunlight, undergo photochemical reactions (reaction pathway) to form ozone (O_3). Toronto shows increasing O_3 episodes towards Saturdays (histogram showing in red the value for each day of the week). Picture courtesy of Ashij Kumar, University of Toronto. For more complete details don't miss reading the full article at page 3.

Page couverture: Les oxydes d'azote (NOx) et les hydrocarbures (Rhs) sont émis par les véhicules et les sources industrielles (illustrés dans le bulbe dans le coin gauche en bas) qui, sous les effets du soleil, sont soumis à des réactions photochimiques (les flèches de réactions) pour former l'ozone (O_3). Toronto démontre des épisodes élevés d'O_3 le samedi (histogramme illustrant en rouge la valeur pour chaque jour de la semaine). L'illustration est une gracieuseté d'Ashij Kumar, Université de Toronto. Pour plus de renseignements, ne manquez pas de lire l'article au complet en page 3.

Next Issue

Next issue of the *CMOS Bulletin SCMO* will be published in April 1999. Please send your articles, notes, reports or news items at the earliest to the address given above. Don't miss your chance!

Prochain numéro

Le prochain numéro du *CMOS Bulletin SCMO* paraîtra en avril 1999. Prière de nous faire parvenir vos articles, notes, rapports ou nouvelles au plus tôt à l'adresse indiquée ci-dessus. Ne ratez surtout pas votre chance!

CMOS - SCMO - CMOS - SCMO

New electronic address →→→→
Nouvelles adresses électroniques →→→→

Canadian Meteorological and Oceanographic Society (CMOS)

Société canadienne de météorologie et d'océanographie (SCMO)

CMOS e-mail address

cmos@meds-sdmm.dfo-mpo.gc.ca
http://www.meds-sdmm.dfo-mpo.gc.ca/cmos/
Adresses électroniques de la SCMO

....from the President's desk

The beginning of the last year of the century (if not the millennium) is a good time to reflect on the future. Two documents landed on my desk that indicate perhaps where our science may be headed and how. The first report was issued in the United States by the National Research Council's Board on Atmospheric Science and Climate, headed by Dr. Joe Friday (former Director of National Weather Service) called "The Atmospheric Sciences Entering the Twenty-First Century". Quoting from news reports, "Weather forecasts of the future could include human health impacts, levels of various pollutants and even the effect of changes in energy from the sun... Temperature, rain, sunshine, wind, humidity and soil moisture may all affect the emergence and spread of infectious diseases... Another opportunity arises with the study of space weather, where variations in the flow of energy from the sun can affect conditions on Earth, particularly electronic communications by radio, television and satellite." Human health-weather and solar weather forecasting appear to be areas of potentially great need in both the United States and Canada - especially in light of growing human sensitivity to the environment and the weather on the one hand, and the ever-growing dependence on global communications by satellite on the other. The United States should be applauded for recognizing this and putting a focus on it for the future. Will Canada be far behind?

Deuxièment, Dr Gordon McBean a annoncé une nouvelle étape dans la démarche de réorientation du Programme de l'environnement atmosphérique, comme réponse à l'étude sur la diversification des modes de prestation de service. Il a décidé de faire des changements au sein du SEA et de créer cinq directions générales dans l'organisation centrale.

Dr. McBean stressed the importance of making stronger links be they between service and science, science and policy or between national and regional prediction centres - as CMOS has tried to emphasize during the ASD hearings and discussions over the last year-and-a-half. Our congratulations should go to Dr. McBean for recognizing the importance of facing the challenges of Canadian meteorology by reforging a strong interlinked service. Along with a stronger structure, perhaps the time has come to make stronger links with human health and solar weather, as appears to be the direction in the United States.

In keeping with the forward-looking tone of this month's column, may I extend best wishes for 1999 to all CMOS members.

Bill Pugsley, President/ Président, CMOS - SCMO

Volume 27 No. 1
February 1999 - février 1999

Inside / En Bref

Articles

Our regular sections / Nos chroniques habituelles

CMOS Annual Congress / Congrès annuel de la SCMO

Printed in Ottawa, Ontario, by M.O.M. Printing
Imprimé sous les presses de M.O.M. Printing, Ottawa, Ontario.

Summer Meteorology Workshop
Project Atmosphere

Call for Applications by Pre-college Teachers

As in several previous years, the Canadian Meteorological and Oceanographic Society (CMOS) has been invited to select a Canadian teacher to participate in PROJECT ATMOSPHERE in 1999. This is a summer workshop for pre-college teachers of Atmospheric Science topics sponsored by the American Meteorological Society (AMS) and the National Oceanic and Atmospheric Administration (NOAA) of the United States. It takes place July 19 - 30, 1999 at the National Weather Service Training Center, Kansas City, Missouri.

The expenses for the participating teacher are paid by AMS/NOAA, except for the travel to and from Kansas City. CMOS and the Canadian Council for Geographic Education contribute up to $300 (Canadian) each (total $600) towards the travel expenses.

Previous Canadian participants have found their attendance a very rewarding and significant experience (see *CMOS Bulletin SCMO*, Vol. 26, No. 5, p. 140). Presentations are made at the Workshop by some of the most respected American Scientists in the fields of atmospheric and oceanographic sciences. Participants have returned with material, resources and teaching modules readily adaptable to classroom presentations.

Interested teachers should request, as soon as possible, an application form from the following address:

Executive Director
CMOS - Summer Workshop
Suite 112, McDonald Bldg
150 Louis-Pasteur
Ottawa, ON K1N 6N5
Tel: (613) 990-0300; Fax: (613) 993-4658
e-mail: cmos@meds-sdmm.dfo-mpo.gc.ca

Atelier d'été en météorologie
Projet Atmosphère

Demande de candidats de niveau pré-collégial

Comme par les années passées, la Société canadienne de météorologie et d'océanographie (SCMO) a été invitée à choisir un enseignant canadien qui participera au PROJET ATMOSPHÈRE en 1999. Il s'agit d'un atelier d'été à l'intention des enseignants de niveau pré-collégial spécialistes en sciences atmosphériques; cet atelier est parrainé par l'American Meteorological Society (AMS) et la National Oceanic and Atmospheric Administration (NOAA) américaine. Il aura lieu du 19 au 30 juillet 1999 au centre de formation du National Weather Service à Kansas City au Missouri.

Les dépenses de l'enseignant choisi seront assumées par l'AMS et la NOAA, à l'exception des déplacements à destination et au retour de Kansas City. La SCMO et le Conseil canadien pour l'enseignement de la géographie offrent chacun jusqu'à 300 $ (canadiens), soit au total 600 $, pour les déplacements.

Les anciens participants du Canada ont trouvé leur expérience très enrichissante et stimulante (lire *CMOS Bulletin SCMO*, Vol. 26, No. 5, p. 140). Les exposés de l'atelier sont présentés par des experts américains les plus réputés dans les sciences atmosphériques et océanographiques. Les enseignants sont revenus avec du matériel, des ressources et des modules didactiques qu'ils peuvent facilement adapter dans leurs cours.

Les enseignants intéressés sont priés de demander un formulaire de candidature à l'adresse suivante :

Directeur exécutif
SCMO - Atelier d'été
Bureau 112, Immeuble McDonald
150, rue Louis-Pasteur
Ottawa (Ontario) K1N 6N5
Téléphone: (613) 990-0300; Télécopieur: (613) 993-4658
Courriel: cmos@meds-sdmm.dfo-mpo.gc.ca

Centres, Chapters and Committees
REMINDER *** REMINDER

Annual reports with financial statements, as appropriate, are now due for the CMOS Annual Review. Please forward them electronically to the Office of the Executive Director, CMOS@meds-sdmm.dfo-mpo.gc.ca with a copy to Paul-André Bolduc, Bolduc@meds-sdmm.dfo-mpo.gc.ca by end of February 1999.

Neil J. Campbell
Executive Director

Centres, Chapitres et Commités
RAPPEL *** RAPPEL

Les rapports annuels avec les états financiers lorsque requis sont maintenant dus pour le rapport annuel de la SCMO. Prière de les faire parvenir par courrier électronique au bureau du Directeur exécutif, CMOS@meds-sdmm.dfo-mpo.gc.ca avec une copie à Paul-André Bolduc, Bolduc@meds-sdmm.dfo-mpo.gc.ca pour la fin de février 1999.

Neil J. Campbell,
Directeur exécutif

Weekend / weekday effect for tropospheric ozone episodes in Ontario, Canada

by Ashij J. Kumar[1], William A. Gough[2] and David Yap[3]

Abstract

Ozone (O_3) episode data spanning 16 years from Ontario, Canada were used to determine the presence of a weekend / weekday effect and to determine if a trend existed for these episodes during this time period. There was a general increase in O_3 episodes during the week with a peak number on Saturdays. The number of episodes decreased on Sundays and further declined on Mondays. The weekend days had statistically significantly more O_3 episodes than weekdays. However the Saturday O_3 episodes showed no temporal trend over the sixteen year period.

Résumé

Des données d'ozone troposphérique couvrant une période de 16 ans en Ontario (Canada) ont été utilisées afin de détecter la présence d'un effet "mileu / fin de semaine", en plus de déterminer s'il existe une tendance pour ces épisodes. On a déterminé qu'il existait en général une augmentation d'épisodes d'ozone troposphérique durant les milieux de semaine, avant d'atteindre un maximum le samedi. Le nombre d'épisodes diminuait ensuite le dimanche et le lundi. Statistiquement, les jours de fin de semaine avaient significativement plus d'épisodes d'ozone que durant les mileux de semaine. Les épisodes d'ozone du samedi n'ont cepandant affiché aucune tendance temporelle durant la période de seize ans.

Source of the problem

The identification of ground level ozone (O_3) as an environmental issue first occurred in the 1950s, in Southern California, where ozone was linked to agricultural crop damage (Godish, 1991). The accumulation of O_3 in the troposphere unlike other pollutants does not significantly arise from direct emission. Ozone is a photochemical oxidant that results from sunlight acting on nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the atmosphere. These O_3 precursors are released into the atmosphere from motor vehicles, point sources (e.g. industries emitting air pollution from various processes using solvents, paints, oils and other chemicals), area sources (e.g. small repair shops, dry cleaners or print shops) and a large number of consumer products (MOEE, 1995; Paul, 1991).

Other factors are also important in the accumulation of ozone. For example, geophysical variables such as high sunlight intensity, warm temperatures, and wind speed contribute to increasing tropospheric O_3 levels (Pryor and Steyn, 1995). Wind plays a role in two ways: (1) calm winds allow precursors to accumulate; and (2) wind can carry pollutants over great distances, increasing O_3 pollution in areas that may not be normally exposed to O_3 precursors (Yap *et al.*, 1997). As well, ozone migration from the stratosphere to the troposphere has been noted occasionally to add to ground level O_3 levels (MOEE, 1995).

Photochemical reactions

The photochemical reactions and the O_3 chemistry that are discussed in this section have been adapted from Godish (1991) and Seinfeld (1975):

Reactions	Notes
1) $NO_2 + h\nu \Rightarrow NO + O$	Initiation reaction provides free radicals to induce the chain reaction; NO_2 is the most important of the initiation reactions
2) $O + O_2 + M \Rightarrow O_3 + M$	M is usually O_2 or N_2 that removes energy of reaction and stabilizes O_3
3) $NO + O_3 \Rightarrow NO_2 + O_2$	Breakdown of O_3 and regeneration of NO_2

[1]Department of Geography, University of Toronto, Toronto, Ontario, M5S 3G3
ash.kumar@utoronto.ca

[2]Environmental Science, University of Toronto at Scarborough, 1265 Military Trail
Scarborough, Ontario, M1C 1A4 gough@scar.utoronto.ca

[3]Environmental Monitoring and Reporting Branch Ontario Ministry of the Environment
125 Resources Road Etobicoke, Ontario M9P 3V6 yapda@ene.gov.on.ca

Since O_3 is consumed via reaction (3) a steady state should be achieved, with O_3 concentrations proportional to NO_2:NO ratios. However, photolysis and oxidation of reactive (non-methane) organic compounds or VOCs provide chemical reactions that convert NO to NO_2 without O_3 consumption and thus elevate tropospheric O_3 levels (Pryor and Steyn, 1995). The following chart shows the generation of NO_2 from NO (without O_3 loss) occurring in the presence of peroxy radicals (RO_2), which are provided by the oxidation of hydrocarbons, and results in O_3 accumulation:

Reactions	Notes
4) $RO_2 + NO \Rightarrow NO_2 + RO$	An increase in NO_2:NO ratio by RO_2 reactions significantly
5) $NO_2 + h\nu \Rightarrow NO + O$	increases O_3
6) $O + O_2 + M \Rightarrow O_3 + M$	
7) Net: $RO_2 + O_2 + h\nu \Rightarrow RO + O_3$	

Weekend / weekday O_3 effect

Ground level ozone has been noted to have a different pattern of behaviour on weekends than on weekdays (sometimes termed as the "Sunday Effect"). Some have found higher or relatively similar ozone concentrations on weekends compared to weekdays (Cleveland *et al.*, 1974; Bruntz et al., 1974; Elkus and Wilson, 1977; Pryor and Steyn, 1995; Summers, 1997). Since weekends are associated with reduced overall emissions of reactive hydrocarbons and NOx, less commuter traffic, and a significant shift of emissions into the evening or non-photochemically active period, it is surprising to find greater or relatively similar O_3 levels on weekends (Elkus and Wilson, 1977). Understanding this weekend / weekday phenomenon has important implications for any control measures that are involved in reducing O_3 levels and may reveal flaws in the assumptions made by current control programs.

In this paper, the frequency of O_3 episodes based on about 45 O_3 monitoring sites across Ontario, Canada, (occurring over 1981 to 1996) were studied to determine whether or not a weekend / weekday pattern was evident for this area and if a temporal trend existed over the 16 years.

Methods

1) Data analyzed

The O_3 data used were provided by Air Quality Information System of the Ontario Ministry of the Environment. The data spanned the years 1981 to 1996 and included days of O_3 episodes in Ontario, Canada. An O_3 episode was defined as a day where widespread levels of O_3 were monitored above Ontario's ambient air quality criterion of 80 ppb (1-h average) that occurred at more than 8 monitoring sites (Yap *et al.*, 1988), compared to typical O_3 levels of approximately 20 ppb (Godish, 1991). Yap *et al.* (1997) provides the geographical distribution of the O_3 monitoring sites. The number of O_3 episodes over the 16-year study period is depicted in Figure 1.

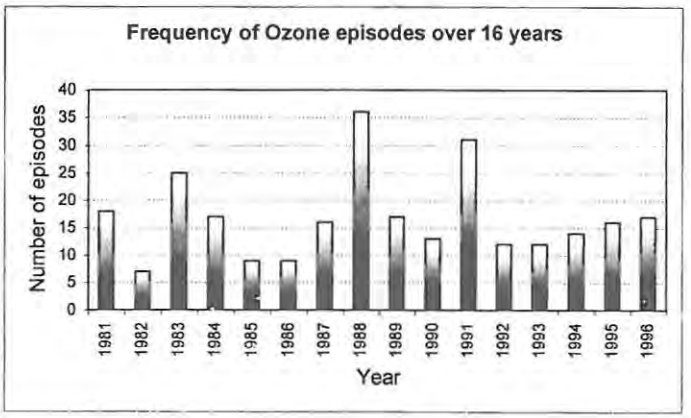


Figure 1: O_3 episodes in Ontario, Canada from 1980 to 1996

Figure 1 shows the number of O_3 episodes over 16 years. An episode occurs when O_3 exceeds 80 ppb (1-h) at 8 or more stations in Southern Ontario. Years with high O_3 episode days include, 1988, 1991 and 1983.

2) Method of analysis

For this study the O_3 episodes for the 16-year period were separated by day of the week and tallied. These data were then plotted to discern any obvious weekly cycles.

Next, the number of episodes from Monday through Friday were averaged to give a representative mean value for the number of episodes during the weekday, while Saturday and Sunday were averaged to give a mean value for the number of episodes during the weekend. In order to test whether there was a significant difference between the weekend mean and the weekday mean episodes, a t-test (of α=0.05) was used. This allowed for a statistical comparison of the means and a determination of whether there was a significant difference in the levels of O_3 episodes between weekend and weekday.

Finally, the Mann-Kendall test for trend and the Wald-Wolfowitz Runs test for randomness were used to determine whether a trend for Saturday O_3 episodes was present over the 16 years of episode data (refer to Gilbert, 1987 and Taylor, 1990 for detailed descriptions of these tests). These tests would reveal whether a trend in the data was present or whether the O_3 episodes were randomly

distributed for this particular day over the 16 years.

Results and Discussion

1) Graphical observation of weekend / weekday effect

Figure 2 shows a plot of the tallied number of O_3 episodes per individual day over the study period. What can be seen from the figure is that O_3 episodes are low on Mondays through Thursdays, increase on Fridays and peak on Saturdays, after which they begin to decline. The weekends have elevated O_3 episodes compared to the weekdays (Saturdays having the highest number of O_3 episodes), which confirm a weekend / weekday effect in Ontario. Recall that the O_3 episodes are days on which there were widespread reported O_3 levels above 80 ppb from a minimum of 8 O_3 monitoring stations in Ontario. So even though these numbers report episodes of high O_3 levels and not concentrations, a differential pattern is still observed for the weekends. Whether this increase in episodes was statistically significant was the next issue addressed.

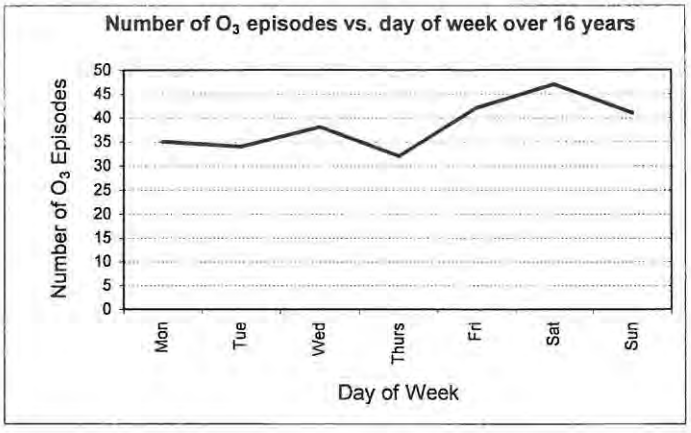


Figure 2: A visual representation of increased O_3 episodes on weekends compared to weekdays

Figure 2 is a plot of increased O_3 episodes by day of the week.

Statistically testing for a weekday / weekend phenomenon

A t-test was employed to determine whether the number of O_3 episodes on weekends was statistically significant compared to the number on weekdays. The test revealed a significant difference (α=0.05) between the means of weekend and weekday episode numbers. Therefore, a difference does statistically exist between the weekend and weekday, with weekends having a greater number of O_3 episodes. Summers (1997) suggested that the changes in precursor emission patterns on weekends should show significant differences in weekday versus weekend O_3 behaviour and found that O_3 concentrations ranged from 10 to 35% higher on weekends at many major urban sites (Montreal, Toronto and Vancouver). The typically higher O_3 concentrations on weekends compared to weekdays could have contributed to the more frequent occurrence of O_3 episodes on weekends in this study.

Since there is a large fractional decrease of primary pollutant concentrations on weekends, due to reduction of automobile traffic, it is expected that O_3 pollutant concentrations would also decrease on weekends (Elkus and Wilson, 1977). However, a number of studies, including this one, have found the opposite. Some possible explanations for this weekend / weekday phenomenon include:

- Feedback within the chemical kinetics of the system. Since NO rapidly attacks O_3 and is a substantial destructive pathway, its reduction during the weekends (with fewer vehicle sources) could lead to increases in weekend O_3 levels (Elkus and Wilson, 1977). This is especially true if VOC concentrations do not decrease as rapidly as NO, maintaining a mechanism for O_3 production.

- Elkus and Wilson (1977) also indicate that meteorological carry over from one day to the next is important. This would include either partially reacted precursor intermediates from earlier days or of O_3 itself.

- Another explanation for this phenomenon has been the distance from urban centers. Karl (1978) found that stations close to the urban center of St. Louis had higher weekend O_3 levels compared to weekdays and the opposite was found for areas far from the urban center.

- Finally, the issue of transboundary O_3 precursor transport has been noted to occur between the Canada / US border (Yap *et al.*, 1997) and would influence O_3 production even when local sources may be reduced, such as on weekends.

The understanding of O_3 episode distribution is important in the regulation of tropospheric O_3 levels. The Canadian Council of Ministers for the Environment (CCME) in 1988 set up the NOx/VOC Management Plan to resolve Canada's O_3 problem by the year 2005 by reducing NOx and VOCs by 25% of 1985 levels (AQRB, 1998). However, for the success of any precursor control program, it is necessary to understand what is causing O_3 accumulation.

Testing for trend / randomness of Saturday O_3 episodes over 16 years

The Mann-Kendall temporal trend test and the Wald-Wolfowitz Runs test for randomness were employed to determine whether a trend in the distribution of the 16 years of Saturday O_3 episodes was present. Saturday was chosen since it had the highest number of O_3 episodes during the week. The Mann-Kendall test for trend was used

since missing values are allowed for and the data do not need to conform to any particular distribution (Gilbert, 1987). The relative magnitudes of the data, as opposed to their measured value, are used to test for a zero slope of the linear regression of time-ordered data against time (Gilbert, 1987). Since O_3 episodes are highly sensitive to meteorological fluctuations (Yap *et al.*, 1997; Brönnimann and Neu, 1997), it is hypothesized that a clear trend over the time series would not be evident. Therefore, in order to verify the possible randomness of O_3 episodes over the 16 years, the Wald-Wolfowitz Runs test was employed. This tests whether the runs (consecutive data points exhibiting a pattern of generally increasing or decreasing value or a group of data points that deviate from a fitted line) in data sets are randomly distributed (Taylor, 1990). If no trend is evident for the O_3 episodes over time, as hypothesized, the runs should be randomly distributed.

First, a plot of O_3 episodes on Saturdays against the time period of 16 years showed little existence of a trend (see Figure 3).

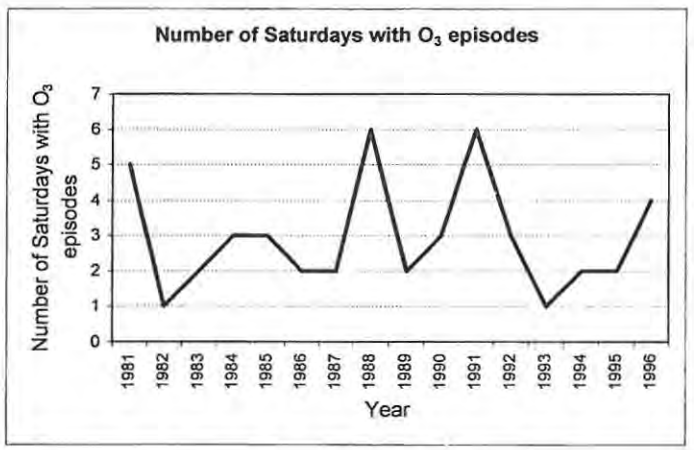


Figure 3: Distribution of Saturday O_3 episodes plotted over 16 years

Figure 3 shows the distribution of Saturday O_3 episodes from 1981 to 1996.

In corroboration, it was statistically shown, using the Mann-Kendall test, that no presence of a trend existed (P=0.05). In support of this, the Wald-Wolfowitz Runs test for randomness concluded that the episodes of O_3 on Saturdays over the 16 years were randomly distributed (P=0.05).

These findings, revealing a random distribution of Saturday O_3 episodes (the day with the highest number of episodes) during the period 1981 to 1996, suggests that this air pollutant problem is not following an increasing trend. Yap *et al.* (1997) have pointed out that O_3 episode days occurred most frequently in the years 1983, 1988, and 1991 (see Figure 1), after which there was a reduction by a factor of two in O_3 episodes. Temperature could possibly be a correlating factor for these years of high episode days. For example, 1988 was a particularly warm year, while 1992 and 1993 were cooler due to the eruption of Mt. Pinatubo. In addition, CEC (1997) infer that since precursor emissions do not drastically change annually, changes in meteorology must drive the fluctuations, with maximum temperatures (as in 1983 and 1988) playing a key role.

Conclusion

Understanding weekend / weekday O_3 activity is important for creating guidelines and regulations for maintaining safe levels of this pollutant. This study has confirmed the existence of the weekend phenomenon in Ontario, Canada consistent with other studies. Further work includes investigating the dependence of the changing levels of O_3 concentration on various factors (i.e. precursor concentration, transport and meteorology) to understand what is controlling the increased levels of O_3 on the weekends. This information will enable better strategies for controlling excessive O_3 levels.

References

AQRB (Environment Canada: Air Quality Research Branch) (visited January 10, 1998). Smog: Modelling/Monitoring. *WWW document*. URL http://airquality.tor.ec.gc.ca/aqrb/smog.htm

Brönnimann, S. and U. Neu, 1997. Weekend-weekday differences of near-surface ozone concentrations in Switzerland for different meteorological conditions. *Atmospheric Environment*, **31**: 1127-1135.

Bruntz, S.M., W.S. Cleveland, T.E. Graedel, B. Kleiner, and J.L. Warner, 1974. Ozone concentrations in New Jersey and New York. *Science*, **186**: 257-259.

CEC (The Canadian Commission for Environmental Cooperation). 1997. Long-Range Transport of Ground-Level Ozone and Its Precursors: Assessment of Methods to Quantify Transboundary Transport Within the Northeastern United States and Eastern Canada. Montréal: Secretariat of the Commission for Environmental Cooperation.

Cleveland, W.S., T.E. Graedel, B. Kleiner and J.L. Warner, 1974. Sunday and workday variations in photochemical air pollutants in New Jersey and New York. *Science*, **186**: 1037-1038.

Elkus, B. and K.R. Wilson, 1977. Photochemical air pollution: Weekend-weekday differences. *Atmospheric Environment*, **11**: 509-515.

Gilbert, R.O. 1987. Statistical Methods for Environmental

Pollution Monitoring. New York: Van Nostrand Reinhold Company.

Godish, T. 1991. Air Quality. 2nd ed. Michigan: Lewis Publishers, Inc.

Karl, T.R. 1978. Day of the week variations of photochemical pollutants in the St. Louis area. *Atmospheric Environment*, **12**: 1657-1667.

MOEE (Ministry of Environment and Energy). 1995. Air Quality in Ontario: 1994 Comprehensive Report. Ontario: Queen's Printer for Ontario (ISSN 0840-9366).

Paul J.A. 1991. Urban Air Quality: The Problem. *EPA Journal*, **17**: 24-26.

Pryor, S.C. and D.G. Steyn, 1995. Hebdomadal and diurnal cycles in ozone time series from the Lower Fraser Valley, B.C. *Atmospheric Environment*, **29**: 1007-1019.

Seinfeld, J.H. 1975. Air pollution: Physical and Chemical Fundamentals. New York: McGraw-Hill Book Company.

Summers, P. 1997. The weekly cycle of ozone and NOx at Canadian sites. In *Ground-level ozone and its precursors, 1980-1993: Report of the Data Analysis Working Group*, edited by Dann, T. and Summers, P. Ontario: Environment Canada, AES (ISSN 1896997007).

Taylor, J.K. 1990. Statistical Techniques for Data Analysis. Michigan: Lewis Publishers, Inc.

Yap, D., D. Fraser, P. Kiley, G. De Brou, and W. Dong, 1997. The Role of Trans-boundary Flow on 1995 Ozone Levels in Ontario, Canada. *AWMA paper* (presentation at the Air and Waste Management Association's 90th Annual Meeting and Exhibition, June 8-13, 1997, Toronto, Ontario, Canada).

Yap, D., D.T. Ning, and W. Dong, 1988. An assessment of source contributions to the ozone concentrations in Southern Ontario 1979-1985. *Atmospheric Environment*, **22**: 1161-1168.

High UVB radiation episode in eastern Canada in March 1993

by Hanna B. Krzeminska[1], Peter L. Jackson[2] and Robert P. Lowe[3]

Abstract

A set of broadband UVB radiation data at 24 locations across Canada (from July, 1992 - December, 1993) was used to reveal levels of UVB radiation flux as well as temporal and spatial differences in Canada. Attention here is given to unusually high UVB fluxes found at the end of March 1993 over the central and eastern part of Canada. Normally high ozone values in the spring were found to fall much below 300 DU causing great UVB radiation enhancements over a 3-5 day period in central and eastern North America. Other atmospheric parameters such as sea level and upper level synoptic analyses were utilized to assess and understand possible causes of spatial and temporal UVB radiation variations at that time. It has been found that all locations east of Winnipeg experienced very high UVB radiation fluxes between 25 and 30 March 1993 except for Goose Bay. At all locations, high UVB fluxes were associated with very low ozone values. The total ozone decrease is a complex problem. Some of the explanations such as breakage of the Arctic vortex, an advection of ozone-poor air from the south and the influence of an upper-level ridge of high pressure are presented and discussed here.

Résumé

Un ensemble de données de radiation UVB à large bande passante provenant de 24 stations à travers le Canada (de juillet 1992 à décembre 1993) a été utilisé afin de révéler les niveaux du flux de radiation UVB (en plus de leurs différences spatio-temporelles) au Canada. Nous portons notre attention aux flux UVB particulièrement élevés qui furent mesurés à travers le centre et l'est du Canada vers la fin de mars 1993 . Les quantités printanières d'ozone - normalement élevées à cette période de l'année - se situaient bien en deça de 300 DU, causant une augmentation marquée du niveau de radiation UVB durant une période de 3-5 jours dans le centre et l'est de l'Amérique du Nord. D'autres paramètres atmosphériques, tels que l'on retrouve dans les analyses synoptiques au niveau de la mer et dans l'atmosphère libre, ont été utilisés pour tenter d'expliquer ces variations spatio-temporelles de la radiation UVB durant cette période. On a ainsi trouvé qu'à toutes les stations à l'est de Winnipeg, des flux de radiation UVB très élevés ont été mesurés entre les 25 et 30 mars 1993, à l'exception toutefois de Goose Bay. À toutes ces stations, les flux d'UVB élevés étaient associés à de très basses quantités d'ozone. La diminution totale d'ozone est un problème complexe. On présente ici quelques explications plausibles, telles la rupture du vortex arctique, l'advection d'une masse d'air pauvre en ozone du sud, et l'influence d'une crête de haute pression en altitude.

1. Introduction

Interest in ultraviolet-B (UVB) radiation levels in the natural environment has been increasing in recent years due to concems that ambient UVB levels will increase as a result of stratospheric ozone depletion. Being the most energetic radiation to which living organisms are exposed, UVB is responsible for most of the solar radiation damage to living organisms, including the possibility of immune suppression in mammals (Goldstein and Reed, 1991; McKenzie and Sauder, 1994). Most of the research on stratospheric ozone decline, and based on it, predictions of UVB radiation increases, have taken place in the vicinity of Antarctica where significant ozone depletion was noticed first and has had a much larger coverage than elsewhere (Häder, 1994; Madronich, 1993; Stolarski et al., 1992; Solomon, 1990).

Fig. 1. Stations measuring broadband UVB radiation in Canada. Shaded area represents approximate region of the highest UVB fluxes that occurred on 25-30 March 1993 (numbers correspond to those in Table 1).

[1]Department of Geography, The University of Western Ontario, London, ON.

[2]Environmental Studies Program, University of Northern British Columbia, Prince George, BC.

[3]Department of Physics, The University of Western Ontario, London, ON.

Location	Prov.	Latitude	Longitude	Location	Prov.	Latitude	Longitude
1 St. John's	NF	47.34	52.43	13 Sudbury	ON	46.3	81
2 Goose Bay	NF	53.18	60.22	14 Windsor	ON	42.18	83.01
3 Halifax	NS	44.39	63.36	15 Thunder Bay	ON	48.24	89.19
4 Fredericton	NB	45.58	66.39	16 Winnipeg	MB	49.53	97.09
5 Saint John	NB	45.16	66.03	17 Regina	SK	50.27	104.37
6 Québec	QC	46.49	71.14	18 Yorktown	SK	53.36	116.27
7 Sherbrooke	QC	45.25	71.54	19 Edmonton	AB	53.33	113.28
8 Ste-Agathe	QC	46.23	71.25	20 Calgary	AB	51.03	114.05
9 Montréal	QC	46.3	73.36	21 Yellowknife	NWT	62.27	114.21
10 Ottawa	ON	45.25	75.42	22 Kamloops	BC	50.4	120.19
11 Toronto	ON	43.4	79.23	23 Vancouver	BC	49.15	123.07
12 Barrie	ON	44.24	79.4	24 Victoria	BC	48.26	123.22

Table 1. Stations measuring broadband UVB radiation and their gegraphical locations (ordered from east to west). Location's numbers correspond to those in Figure 1.

With the development of UVB measuring instruments, measurement of solar radiation under different natural conditions became possible. UVB monitoring stations allow for collection of data that can be analysed to reveal actual levels, as well as spatial and temporal behaviour of surface UVB radiation. Broadband UVB irradiance in Canada has been measured with the Solar Light UV-Biometer 501 at 24 locations across the country (Table 1, Figure 1) since July 14, 1992 by "The Weather Network-Météomedia". Analysis of this data set, including all measurements until December 31, 1993 revealed increased levels of UVB radiation accompanied by low values of ozone at most of the eastern Canadian locations on several days at the end of March 1993. Therefore, our attention here is focused on the spring of 1993. We document the spatial extent of the episode and show the co-occurrence of the areas of high UVB and low ozone. We will identify associations and processes thought to cause the ozone decrease and UVB radiation increase at that time.

2. Data and Instrumentation

The amount of solar ultraviolet radiation at the Earth's surface shows large variations by local time, latitude and month. These variations result mainly from the elevation of the sun above the horizon (Frederick, 1990). Variations in ozone and other atmospheric parameters, especially cloudiness, may also substantially change the shape of daily as well as seasonal distribution of UVB irradiance (Madronich, 1993). Analysis of UVB irradiance data, weather data, and ozone data was undertaken in order to establish surface UVB levels and UVB radiation responses to variations in atmospheric transparency.

2.1 Broadband UVB data

The UV-Biometer 501 (Robertson-Berger (RB) instrument) utilized by "The Weather Network-Météomedia's" broadband UVB network measures biologically effective radiation with wavelengths above 280 nm (Robertson, 1972; Berger, 1976; Berger and Urbach, 1982; Blumthaller et al., 1993). The spectral response of the instrument resembles that of human skin's erythema action spectrum (Solar Light Co., 1991). A cross-calibration of similar RB meters with the Brewer spectrophotometer was performed by Krzeminska (1995). The results (1.5 " 0.5% difference per day) show a good agreement between the broadband RB meter and the benchmark spectral measurements of the Brewer. A comparison of the two types of instruments (Brewer No. 64 and a Solar Light 501 A) was performed by Krzyscin and Jaroslawski (1997). Similarly, the authors found a good correlation between the instruments. The fractional deviations of the UVB daily doses from the Brewer spectrophotometer compared to those from the broad band RB radiometer produced correlation coefficients with $r^2 = 0.99$ for all-skies condition and 0.90 and 0.98 for clear and overcast skies respectively. The measurements used are 5 minute averages from 24 locations for the period of 18 months starting from July 1992. All data taken between sunrise and sunset have been used.

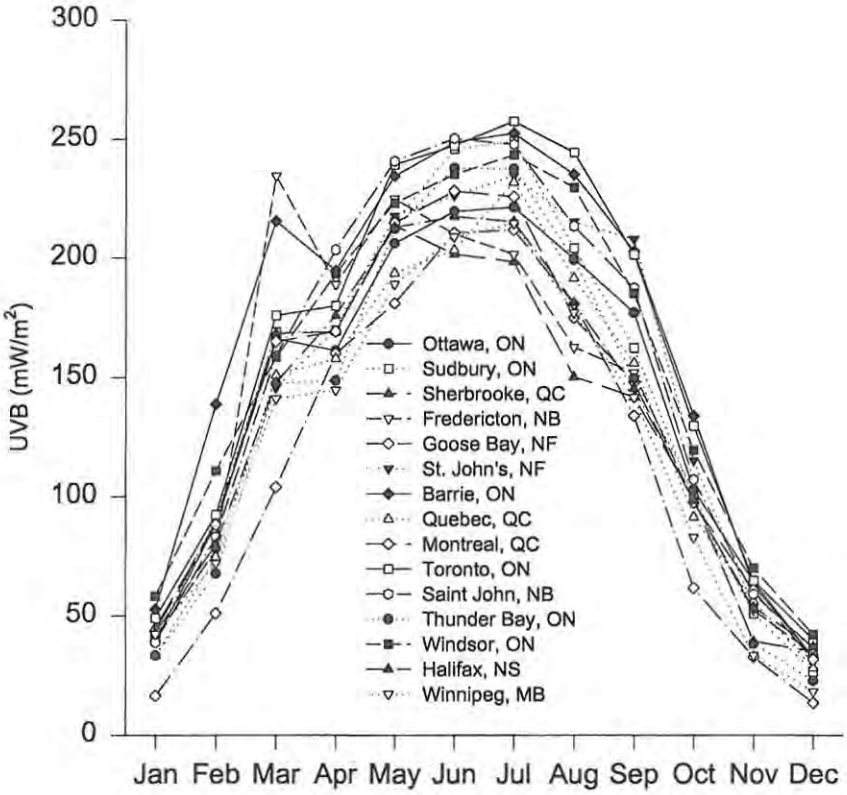


Fig. 2a). Annual distribution of monthly maximum UVB radiation in central and eastern Canada in 1993.

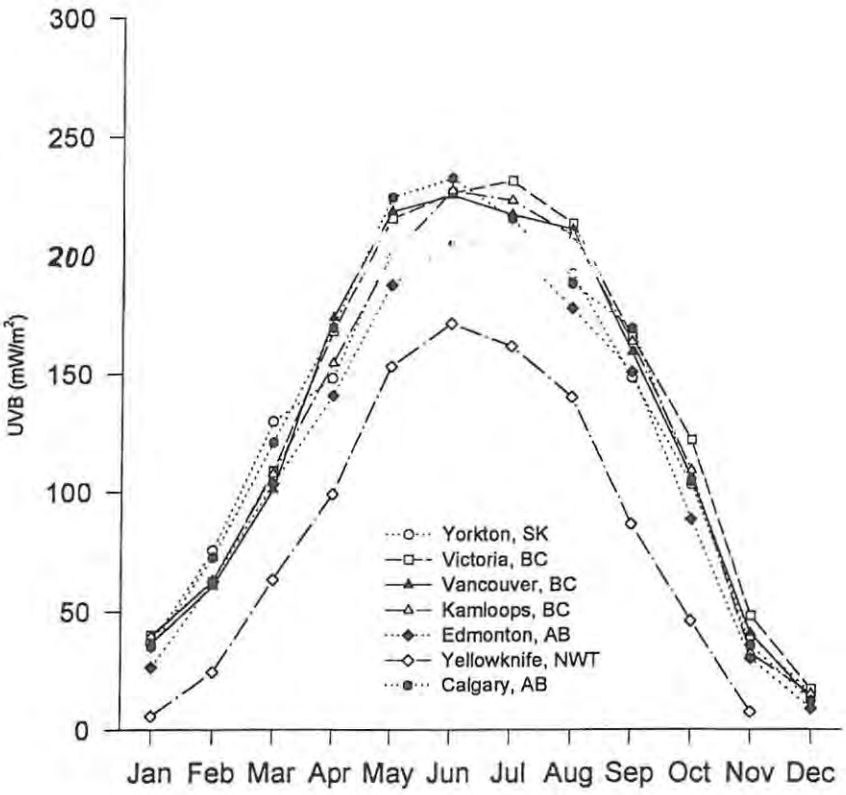


Fig. 2b) Annual distribution of monthly maximum UVB radiation in western Canada in 1993.

2.2 Total ozone data

It is well known that the most effective atmospheric constituent for absorption of UVB radiation is ozone (O_3) (e.g. Blumthaler, 1993). Total ozone data from the Goddard Space Flight Center in Maryland, consist of daily total ozone measurements at 1.25 degree longitude and 1 degree latitude resolution produced by the Nimbus-7 (McPeters et al., 1996) and Meteor-3 (Herman et al, 1996) satellites (Version 7.0). As Nimbus-7 terminated its activity on May 06, 1993, the Meteor-3 data were used as its continuation. Close agreement (1 % bias) between the two data sets was shown by Gleason et al. (1993) and mentioned by Herman and Larko (1994).

3. Areal extent of the high UVB fluxes in March 1993

Analyses of mean and mean maximum ultraviolet radiation at 21 locations across Canada for the period from July 1992 to December 1993 revealed that, at all eastern locations except for Goose Bay, the UVB radiation readings in March, 1993 were higher than expected by over 10 % (Krzeminska, 1995). Figure 1 presents the approximate region of the higher UVB irradiance episode at the time. Annual distributions of monthly maximum UVB radiation in western and eastern parts of the country in 1993 are shown in Figures 2a and 2b. The increases are also noticeable in the monthly mean UVB irradiance data as characteristic peaks in all eastern locations in March (e.g. Figure 3a). Figure 3b presents an example of a typical monthly mean UVB flux distribution in western Canada in 1993.

Analysis of the daily integrated UVB irradiances revealed elevated UVB radiation levels on 25-30 March 1993 in all locations considered except: Victoria, Vancouver, Kamloops, Calgary, Edmonton, Yellowknife and Goose Bay. Vancouver and Edmonton experienced a higher UVB flux earlier, on 22 March, but this situation did not last more than one day. Figures 4a and 4b present examples of daily integrated UVB irradiance for some eastern (Barrie, Ste-Agathe and Halifax) and some western (Victoria, Kamloops and Yellowknife) locations respectively between 11 March and 05 April 1993.

Low values of daily mean total ozone were found for all days with high UVB irradiance readings (25-30 March) in all eastern locations (except Goose Bay). They were well below 300 DU, with most lying in the range of 260-280 DU. There were no such decreases in O_3 noted at the stations without high UVB radiation levels during this time. Since considerable decreases in total ozone relative to previous years, starting from the summer 1992 and continuing into the early summer of 1993, were observed in the northern Hemisphere (Hilsenrath et al., 1996; Gleason et al., 1993; Herman and Larko, 1994; Kerr and McElroy, 1993; Siani et al., 1993), daily total ozone values became a basis for further investigation into reasons for the increased UVB radiation levels in eastern Canada in March 1993.

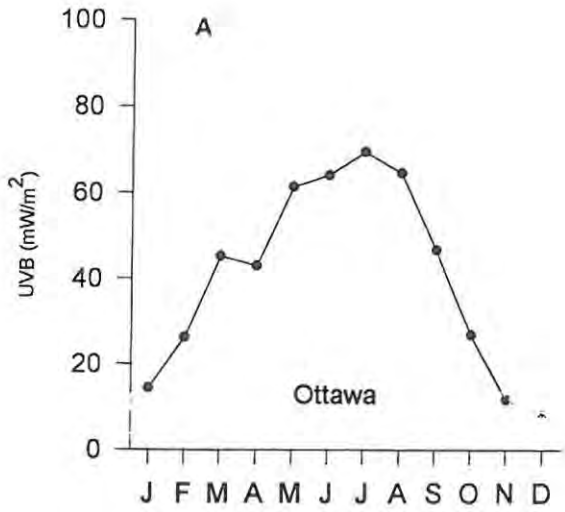


Fig. 3. a) Distribution of monthly mean UVB radiation in Ottawa in 1993

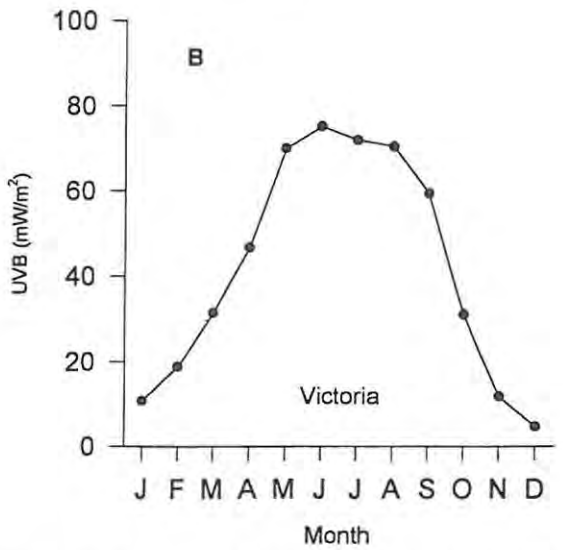


Fig. 3b). Distribution of monthly mean UVB radiation in Victoria in 1993

4. Mechanism for low total ozone in March 1993

The area of UVB increase (Figure 1) corresponds to the area of ozone decrease during 25-30 March (see Figures 5-7a). Therefore, we consider the spatial extent of ozone decrease representative of the area of high UVB radiation fluxes during this time. The question remains, however, what caused the low ozone in central and eastern Canada in March 1993? Surface and upper-level weather maps (500, 200, 100 and 20 hPa, with 200 and 20 hPa maps shown here), as well as total ozone images were utilized while investigating this issue.

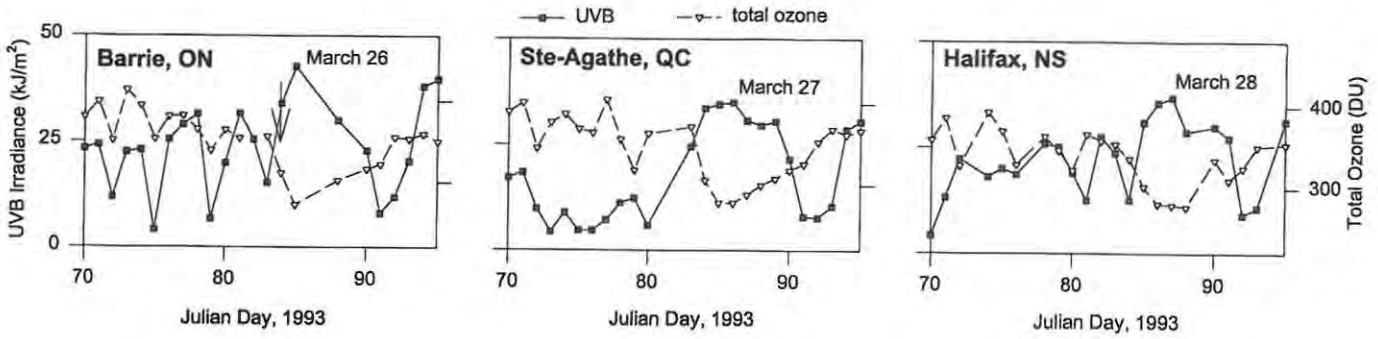


Fig. 4a). Daily integrated UVB irradiances (solid line) and total ozone (dashed line) at Barrie, Ste-Agathe, and Halifax between 11 March and 05 April 1993. The labelled date is the time of maximum UVB irradiance.

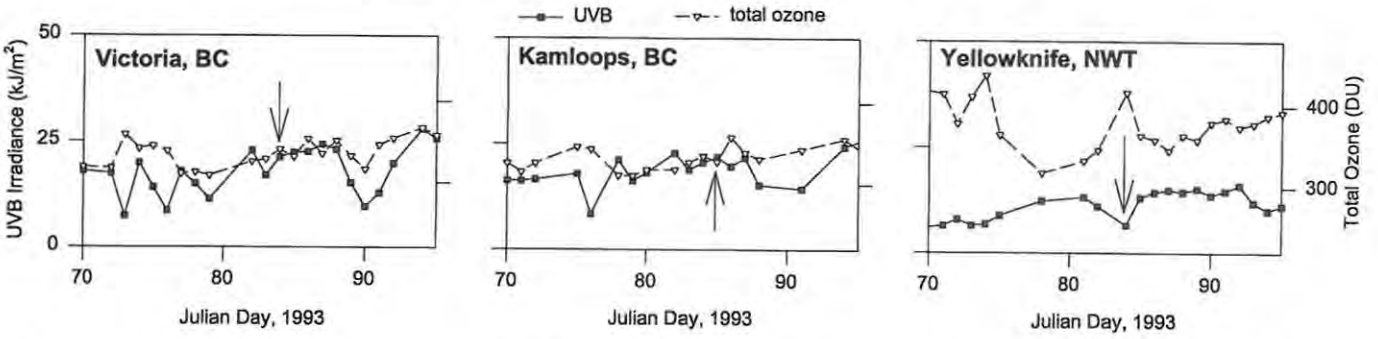


Fig. 4b). Daily integrated UVB irradiances (solid line) and total ozone (dashed line) at Victoria, Kamloops and Yellowknife between 11 March and 05 April 1993. The arrow points out 25 March.

4.1 Upper level ridge

According to Kerr and McElroy (1993), the low average amount of total ozone in Toronto in the spring of 1993 resulted from several very low ozone values (around 260 DU) measured at the end of March. The authors associate these low ozone values with a ridge of high pressure which built over central and eastern Canada after 25 March. Upper-level weather maps (not shown) indicate a ridge of high pressure developing over the Pacific Ocean close to the west coast on 22 March. The western part of the country was under the influence of this system on 23 and 24 March. It was, however, not well established over western Canada before moving east followed by a low pressure system, which might have caused ozone to stay at normal levels in most western locations. The long lasting high pressure system over the eastern part of Canada (Figures 5-7b) is a likely cause of the low ozone values. As mentioned by Kerr and McElroy (1993), explained by Dobson (1968), and confirmed by the study of geopotential fields (at 200 and 300 hPa) and total ozone correlations of Shalamyansky and Romashkina (1980), low ozone may result from high pressure in the upper troposphere and high ozone values from low pressure. The upper-level ridge at the end of March 1993 was associated with high surface pressures (mean sea-level pressure above 1024 hPa). Such a ridge building with height (i.e. a warm ridge) results in vertical expansion of the troposphere and contraction of the ozone-rich stratosphere. The thinner stratosphere thus contains relatively less ozone; moreover, such a synoptic weather pattern also brings fair weather conditions (few clouds and better atmospheric transparency) enabling more UVB radiation to reach the surface. Figures 5-7c) show height anomalies – the difference between the 200 hPa heights and the 1979 – 1995 March mean heights. The shaded areas in these figures indicate locations where the height anomaly is greater than 2 standard deviations from the 1979-1995 March mean height. Comparison of Figures 5-7a) with Figures 5-7c) indicates a very close association between the extent and position of the 200 hPa positive height anomaly with the area of low total ozone over central Canada during this time.

4.2 Intense cyclone

Michaels et al. (1993) suggest that the deepest surface cyclone (below 965 hPa) in the 20th century observed around 12-14 March1993 in the northeastern U.S. caused the ozone decrease. TOMS images, however, show normal to high ozone values (350-400 DU) at that time over all of North America. Moreover, decreasing ozone readings in central Canada are observed to take place about 10-12 days later. Atmospheric (and ozone) conditions may change considerably over such a long period of time.

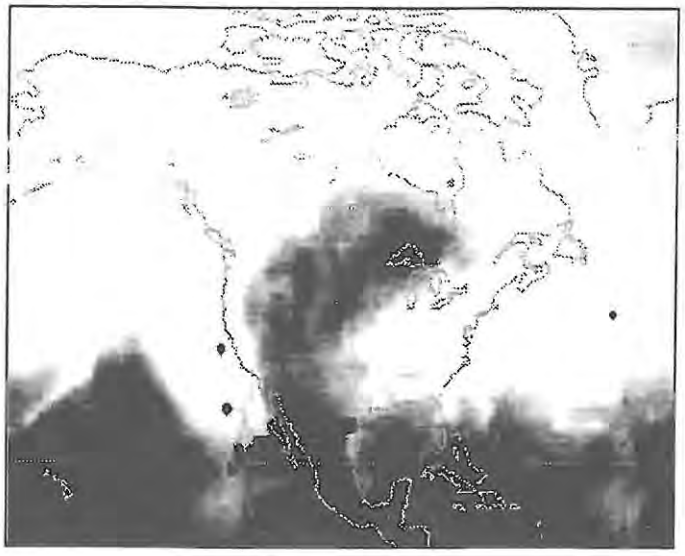


Fig. 5a). Total ozone distribution (from Nimbus-7 TOMS), 25 March 1993. White areas represent values over 300 DU, darkest areas represent values below 275 DU. The northern extension of minimum ozone in black seems to correlate well with the 11880 m contour (black regular shapes and circles in these figures represent areas with missing data).

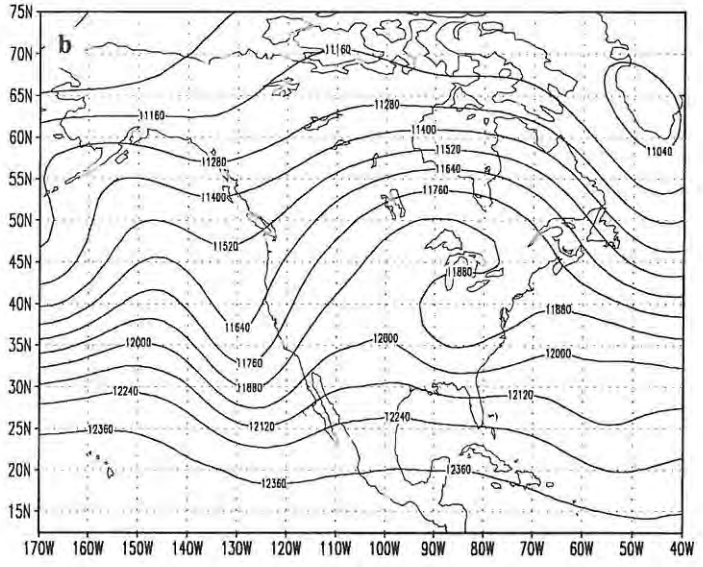


Fig. 5b). Upper-level air chart (200 hPa).

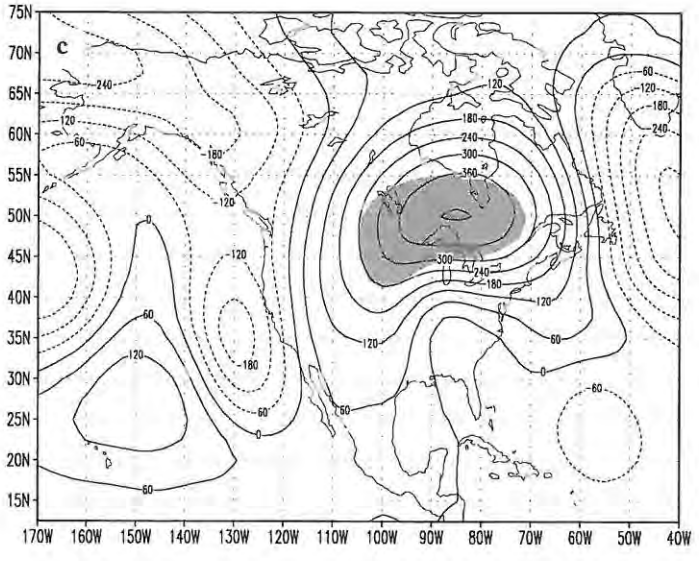


Fig.5c) 200 hPa height anomalies. Shaded area represents anomalies greater than 2 standard deviations from the 1979-1995 March mean height field.

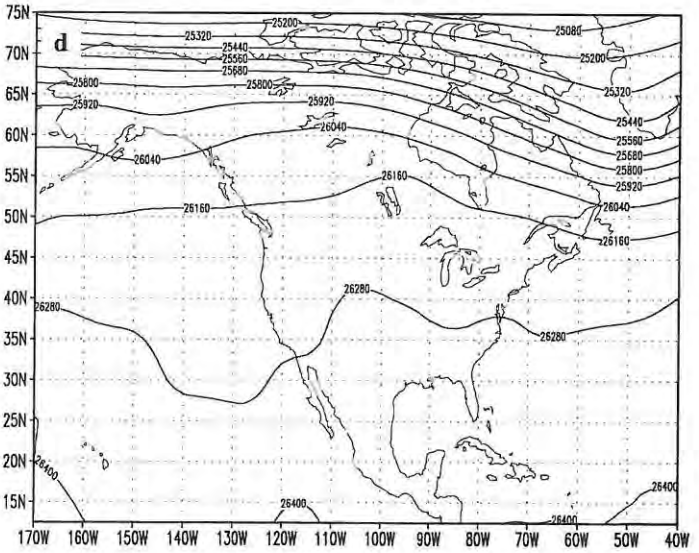


Fig. 5d). 20 hPa height field.

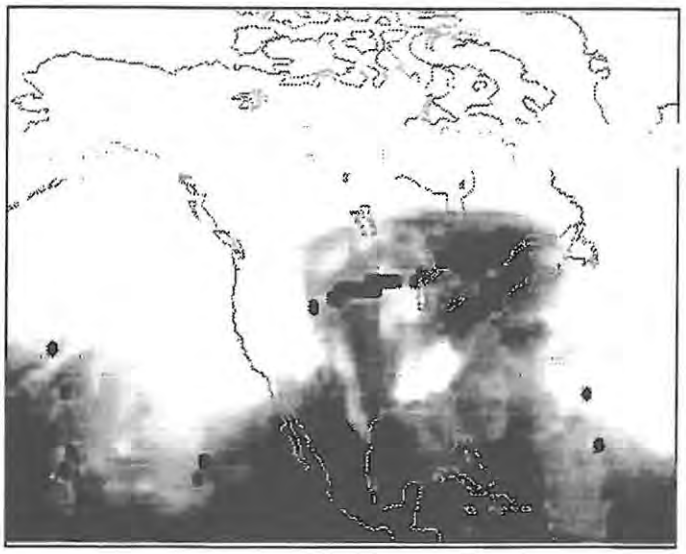


Fig. 6a). Total ozone distribution (from Nimbus-7 TOMS), 27 March 1993. White areas represent values over 300 DU, darkest areas represent values below 275 DU. The northern extension of minimum ozone in black seems to correlate well with the 11880 m contour (black regular shapes and circles in these figures represent areas with missing data).

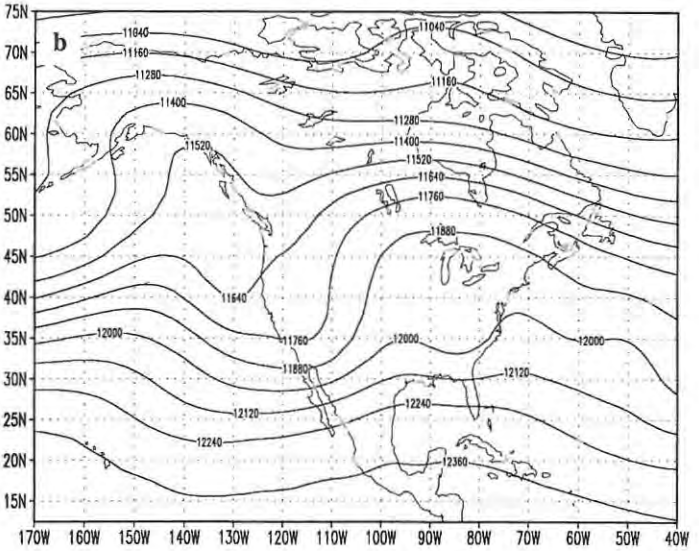


Fig. 6b). Upper-level air chart (200 hPa).

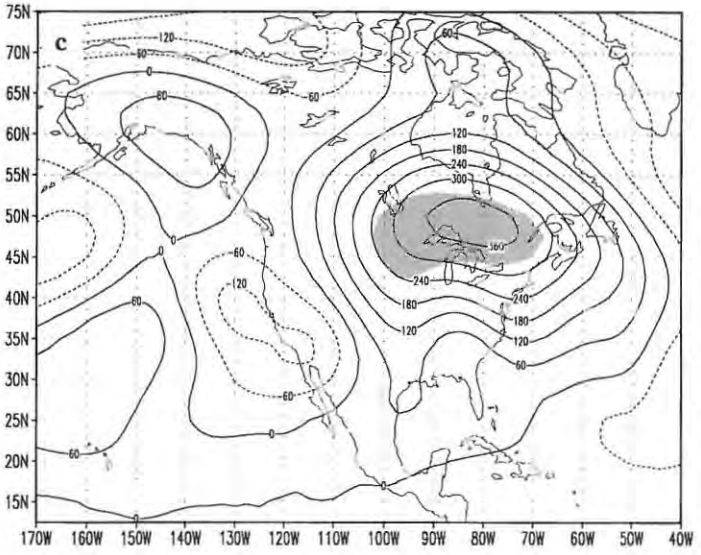


Fig.6c) 200 hPa height anomalies. Shaded area represents anomalies greater than 2 standard deviations from the 1979-1995 March mean height field.

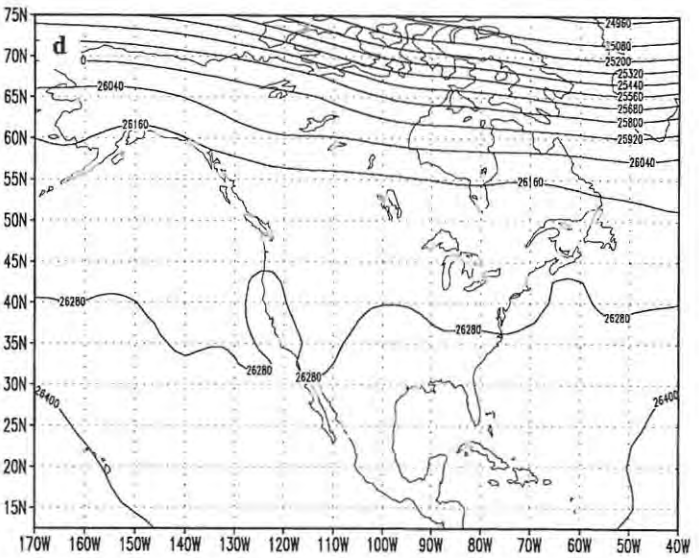


Fig. 6d). 20 hPa height field.

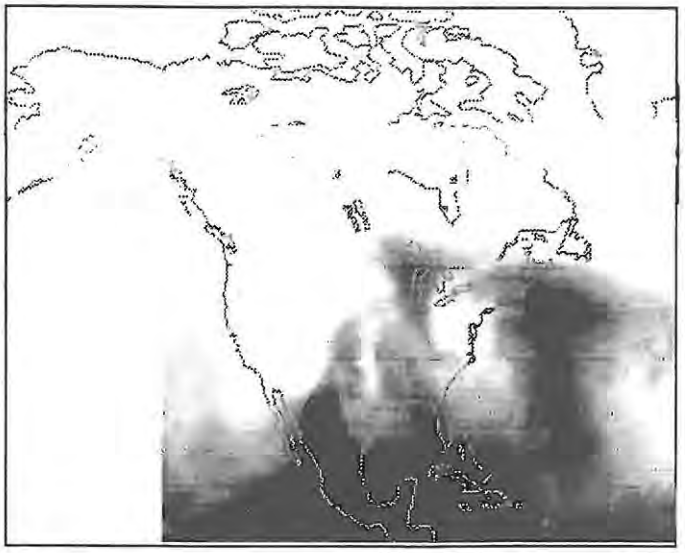


Fig. 7a). Total ozone distribution (from Nimbus-7 TOMS), 29 March 1993. White areas represent values over 300 DU, darkest areas represent values below 275 DU. The northern extension of minimum ozone in black seems to correlate well with the 11880 m contour (black regular shapes and circles in these figures represent areas with missing data).

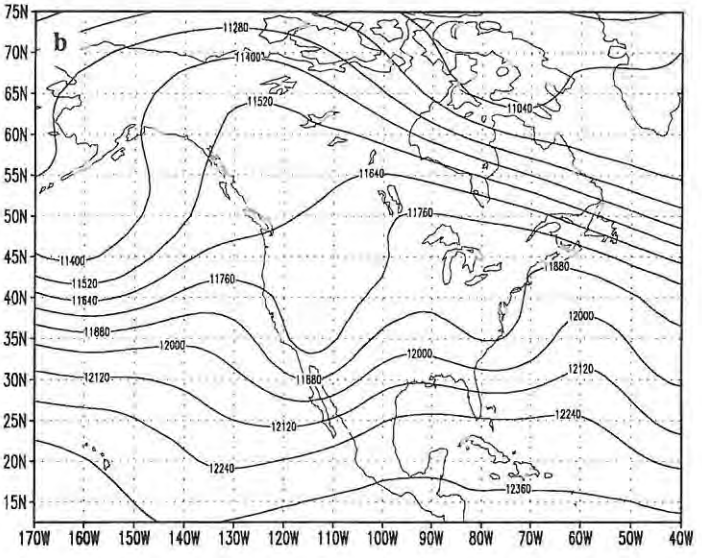


Fig. 7b). Upper-level air chart (200 hPa).

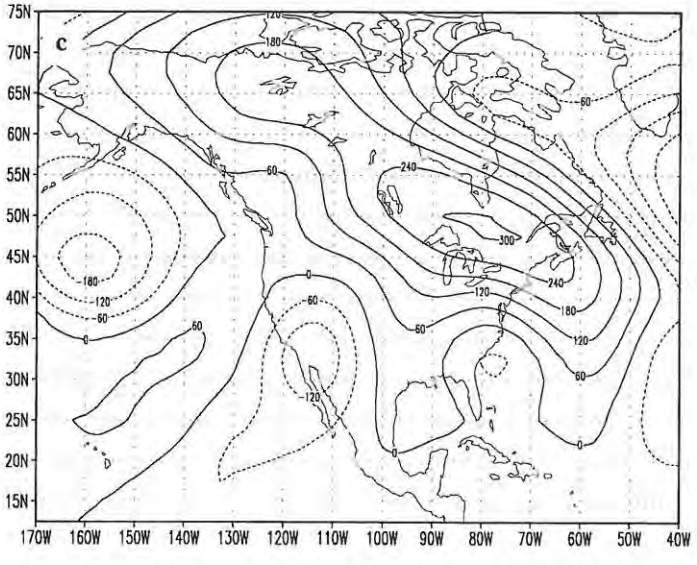


Fig.7c) 200 hPa height anomalies. Shaded area represents anomalies greater than 2 standard deviations from the 1979-1995 March mean height field.

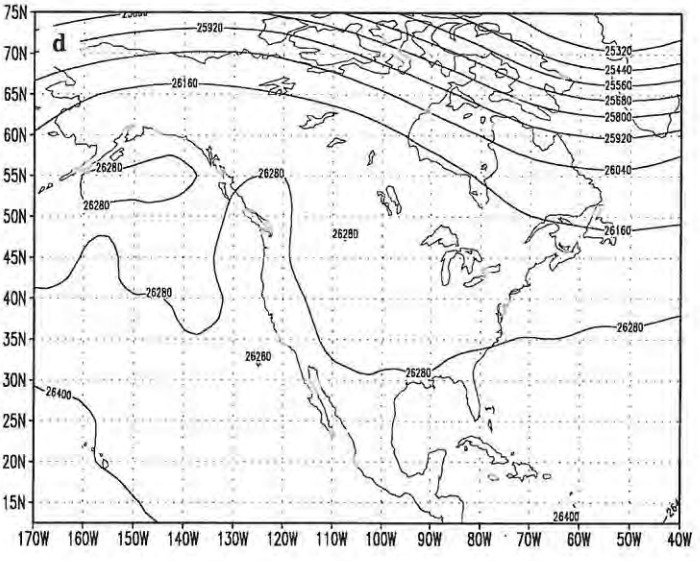


Fig. 7d). 20 hPa height field.

4.3 Transport of air from the polar vortex

Another explanation for the low ozone readings in March 1993 could have been the transport of ozone-poor air southward from the Arctic vortex which was tracked by Microwave Limb Sounder over northeastern Canada in mid-February (Waters et al., 1993). The low temperatures in the vortex are necessary for the formation of polar stratospheric clouds (PSCs) where heterogeneous chemistry resulting in ozone destruction occurs. Such conditions could have supported great ozone loss later in the spring when more UVB radiation was available. According to Waters et al. (1993), chlorine (ClO) concentration was high throughout February; however, ozone destruction by ClO in the northern hemisphere in March of 1993 was limited as the temperatures in the lower stratosphere raised at the end of February 1993 causing a decrease of the chlorine amount. Nevertheless, the average ozone column above 200 mb during the late winter of 1993 was about 10 % lower than at the same time in 1992 (Waters et al., 1993).

According to Bojkov et al. (1993) there is also a possibility of the transport of chlorine-rich air from the polar vortex to the sunlit mid-latitudes where it may cause chemical destruction of ozone. Other possible ozone-depleting mechanisms such as changes in the equator-to-pole diabatic circulation and the Mount Pinatubo eruption in July 1991 are mentioned by Herman and Larko (1993). Generally low ozone levels measured in 1992 and 1993 are likely to be related to elevated amount of volcanic aerosols (Planet et al, 1994; Kerr et al., 1993; Gleason et al., 1993); however, some other conditions must have occurred to support such a great ozone decrease on the particular days at the end of March 1993.

Analysis of 20 hPa height fields (Figures 5-7d) show a somewhat stronger than normal polar vortex – height anomalies within the vortex (not shown) range from -1000 m to -600 m during the 25-30 March 1993 period which can be scaled against a 20 hPa height standard deviation of 650 m in the location of the polar vortex. There is no indication in Figures 5-7d) of stratospheric transport of either ozone-poor or chlorine-rich air from the polar vortex to the areas in eastern Canada which experienced the abnormally low ozone values. Analysis of 20 hPa fields from February through the end of March 1993 (not shown), likewise did not indicate southward stratospheric advection of polar vortex air in the period preceding the event. The polar vortex, as represented by 20 hPa analyses, did shift across the northern hemisphere, but at no time did the core of the vortex extend over eastern-central Canada.

4.4 Transport of ozone-poor air from the south

Analysis of TOMS images of ozone (Figures 5-7a) for days with high UVB fluxes in March 1993 suggests that ozone decreases on these days could also be driven by an intrusion of ozone-poor air from the south. On 25 March 1993 (Figure 5a) the area of low ozone values was observed to extend north from the tropical zone encompassing central U.S. and central Canada. The lowest ozone amounts (under 300 DU) affected most of the southern part of Canada from Winnipeg to Barrie at the time. Between 25 and 29 March (Figures 5-7a) the cell of very low ozone values (below 260 DU) moved over and to the east of the Great Lakes area. By 29 March it was observed to be heading southeast from the Canadian east coast (Figure 7a). The low ozone cell retreated totally from Canadian territory by 31 March, 1993.

While the cell of low ozone values appears, as previously discussed, to be associated with the upper tropospheric (200 hPa) height field, flow at this level cannot be used to account for advection in the stratosphere. Inspection of lower stratospheric (20 hPa) height fields both preceding (not shown) and during (Figures 5-7d) the episode provides no indication that stratospheric advection of ozone-poor air from the south could account for the low ozone values at the end of March 1993.

The upper-tropospheric ridge might however be associated with the movement of naturally ozone-poor air from the troposphere of the tropical areas, to the stratosphere over the area of interest. Bojkov et al. (1993) studied low ozone cases by examining trajectories on potential temperature surfaces, confirming the possibility of ozone-poor air advection from the sub-tropical upper troposphere to the mid-latitude lower stratosphere. The trajectory of the low ozone cell of air seems to follow the flow around the 200 hPa ridge. On 25 March, the 200 hPa map (Figure 5b) shows a ridge of high pressure extending across the North American continent from the southwest toward the Canadian east coast. The strongest flow of air is oriented from the southwest across the west and central part of the U.S., towards Hudson Bay. The direction of this circulation, also dictated by a stable low pressure system over southeastern U.S., can advect low-ozone air from the tropical zone over eastern Canada. The slow eastward movement of the ridge and the accompanying low can be observed on subsequent days. At the same time ozone values slightly increase over the Great Lakes area and decrease to the east following the movement of the upper ridge. On 27 March (Figure 6), both the ridge and the eastern U.S. low move further east. The flow from the south driven by the ridge receding to the northeast is now stronger in front of this low pressure system. The new flow is accentuated over the Atlantic, stretching towards the Canadian east coast. By 31 March, both pressure systems retreat from the continent and most of the Canadian territory is under northerly flow (higher ozone values) caused by the circulation around the low pressure system over Newfoundland.

5. Conclusion

Unusually high UVB radiation fluxes on 25-30 March 1993 in 17 locations in eastern Canada were undoubtedly caused by the very low ozone values measured at the same time. The spatial scale of this event in Canada has not previously been reported in the literature, except for the announcement of high UVB radiation fluxes in Toronto (Kerr and McElroy, 1993). There is, however, some uncertainty regarding the cause of low ozone readings. It is suggested that the low stratospheric ozone levels resulted from the presence of an anomalous upper-level tropospheric ridge over the area during this time. We believe that the ridge acted in one or both of the following ways:

i) the deep troposphere associated with the ridge resulted in a vertical contraction of the stratosphere and hence a reduction in the total ozone contained in the thinned stratosphere;

ii) the upper tropospheric flow pattern associated with the ridge resulted in advection of ozone-poor air from the tropical troposphere to the mid-latitude stratosphere over eastern Canada during this time.

The strong association observed between the 200 hPa height anomalies and the cell of low ozone are strongly suggestive of (i), while TOMS total ozone images for the month of March indicate possible advection of ozone-poor air from the sub-tropical areas may be important. As upper level ridges are associated with lowered total ozone amounts (Dobson, 1968), and the circulation around the ridge seems to confirm the possibility of an ozone-poor air advection from the south, the upper ridge over eastern Canada is regarded as the most important cause of low ozone values and high UVB irradiances in this region at the end of March 1993.

Acknowledgements

The authors would like to thank "The Weather Network-Météomedia" for providing UVB radiation data and Atmospheric Environment Service of Environment Canada for weather data. This work was partially supported by the Canadian Network for Space Research and an AES/NSERC Science Subvention. Some figures were produced by Corinna Elnyiuk.

References

1) Berger, D.S. and F. Urbach. 1982. A climatology of sunburning ultraviolet radiation. *Photobiology and Photochemistry*. 35, 187-192.

2) Berger, D.S. 1976. The sunburning ultraviolet Meter: Design and Performance. *Photobiology and Photochemistry*. 24, 587-593.

3) Blumthaler, M. 1993. UV-B Radiation and Ozone Depletion. Effects on Humans, Animals, Plants, Microorganisms, and Materials. *Ed. M. Tevini. Lewis Publishers*. London.

4) Bojkov, R.D., Zerefos, CH.S., Balis, D.S., Ziomas, I.C. and A.F. Bais. 1993. Record low total ozone during northern winters of 1992 and 1993. *Geophys. Res. Lett.* **20 (31)**, 1351-1354.

5) Dobson, G.M.B. 1968. Exploring the Atmosphere. *Clarenon Press.* Oxford.

6) Frederick, J.F. 1990. Trends in atmospheric ozone and UV: Mechanisms and observations for the Northern Hemisphere. *Photoch.Photob.* **51**(5), 757-763.

7) Gleason, J. F., P. K. Bhartia, J. R. Herman, R. McPeters, P. Newman, R. S. Stolarski, L. Flynn, G. Labow, D. Larko, C. Seftor, C. Wellmayer, W. D. Komhyr, A. J. Miller and W. Planet. 1993. Record low global ozone in 1992. *Science.* **260**, 523-525.

8) Goldstein, B.D. and D.J. Reed. 1991. Global atmospheric change and research needs in environmental health sciences. *Envir. Health Persp.* **96**,193-196.

9) Häder, D., 1994. UV-B effects on aquatic systems. *Stratospheric Ozone Depletion/UVB Radiation in the Biosphere. NATO ASI Series*. Springer-Verlag. New York, 155-161.

10) Herman, J. R., P. K. Bhartia, A. J. Kruger and R. D. McPeters. 1996. *METEOR-3 Total Ozone Mapp Spectrophotometer (TOMS) data products user's guide.* NASA Reference Publications.

11) Herman, J.R. and D. Larko. 1994. Low Ozone amounts During 1992-1993 from Nimbus 7 and Meteor 3 Total Ozone Mapping Spectrometers. *J. Geophys. Res.* **99** (D2), 3483-3496.

12) Hilsenrath, E., P.A. Newman, R. Cebula, P.W. Decamp, T.J. Kelly. 1996. Ozone change from 1992 to 1993 as observed from SSBUV on the ATLAS-1 and ATLAS-2 missions. *Geoph. Res. Lett.* **23**, NO. 17, 2305-2308.

13) Kerr, J.B. and C.T. McElroy. 1993 Evidence for large upwards trends of ultraviolet radiation linked to ozone depletion. *Science.* **262**, 1032-1034.

14) Kerr, J.B., D.I. Wardle and D.W. Tarasick. 1993. Record low ozone values over Canada in early 1993. *Geophys. Res. Lett.* 20, NO.18:1979-1982.

15) Krzeminska, H. 1995. *Distribution of ultraviolet B radiation in Canada.* MSc. Thesis. UWO, London, Ontario.

16) Krzyscin, J. W. and J. Jaroslawski. 1997. Factors affecting solar UV ardiation changes: a study of the new Robertson_Berger meter (UV-biometer 501 A) and Brewer data records taken at Belsk, Poland, 1993-1994. *J. of Atm. & Solar-Terr.* Phys. **59 (10)**, 1133-1142 .

17) Madronich, S. 1993. UVB radiation in the natural and perturbed atmosphere. *UV-B Radiation and Ozone Depletion. Effects on Humans, animals, Plants, Microorganisms, and Materials.* Edited by M. Tevini. Lewis Publishers. London, 17-69.

18) McKenzie, R.C. and D.N. Sauder. 1994. Ultraviolet radiation: Effects on the immune system. *Annales CRMCC.* 27, 20-26.

19) McPeters R.D., P.K. Bhartia, A.J. Kruger and J.R Herman. 1996. *NIMBUS-7 Total Ozone Map Spectrophotometer (TOMS) data products user's guide.* NASA Reference Publications.

20) Michaels, P.J., S.F. Singer and P. C. Knappenberger. 1993. Analyzing ultraviolet-B radiation: Is there a trend? *Science.* **264**, 1341-1342.

21) Planet W.G., J.H. Lienesch, A.J. Miller, R. Nagatani, R.D. McPeters, E. Hilsenrath, R.P. Cebula, M.T. DeLand, C.G. Wellemeyer and K. Horvath. 1994. Northern hemisphere total ozone values from 1989-1993 determined with the NOAA-11 Solar Backscatter Ultraviolet (SBUV/2) instrument. *Geophys. Res. Lett.* **21 (3)**, 205-208.

22) Robertson D.F. 1972. *Solar ultraviolet radiation in relation to human sunburn and skin cancer.* Ph.D. Thesis. University of Queensland.

23) Siani, A.M., N.J. Muthama and S. Palmieri. 1993. Total ozone and UV-B behavior in 1992/1993 at Mid-Latitude Station. *Stratospheric Ozone Depletion UV-B Radiation in the Biosphere.* Edited by Biggs and Joyner. Horticultural Science Faculty, University of Florida. NATO Sci. Affairs Div.
Solar Light Co., 1991. *Solar UV-Biometer Model 501.* Manual.
24) Solomon, S. 1990. Progress towards a quantitative understanding of Antarctic ozone depletion. *Nature.* **347,** 347-354.
25) Stolarski, R., R. Boykow, L. Bishop, CH. Zerefos, J. Staehelin and J. Zawodny. 1992. Measured trends in stratospheric ozone. *Science.* **256,** 342-349.
26) Shalamyansky, A.M. and K.I. Romashkina. 1980. Distribution and total ozone variations in various air masses. *Izv. USSR Ac. Sci.* **16,** NO.12, 1258-1265.
27) Waters, J.W., L. Froidevaux, W.G. Read, G.L. Manney, L.S. Elson, D.A. Flower, R.F. Jarnot and R.S. Harwood. 1993. Stratospheric ClO and Ozone from the Microwave Limb Sounder on the Upper Atmosphere Research Satellite. *Nature.* **362,** 597-602.

Letters to the Editor

Nick Fofonoff receives Henry Stommel Research Award

Canadian-born oceanographer Nick Fofonoff was the 1998 recipient of the prestigious Henry Stommel award of the American Meteorological Society for (read the citation) "his fundamental work on the general circulation and the physical properties of the ocean and for the development of observational techniques in physical oceanography."

Nick was born in British Columbia, of a Doukhobor family. His early love of science brought him to the University of British Columbia, where he obtained a B.A. and an M.A. in Mathematics and Physics in 1950 and 1951 respectively. He then went on to a Ph.D. at Brown University. His thesis, on theoretical aspects of wind-driven ocean circulation, was an important contribution to a rapidly developing subject. Following a post-doc at the National Institute of Oceanography (Wormley, UK), Nick returned to B.C. and worked until 1962 with the Pacific Oceanographic Group, in Nanaimo. His most important work during that period included extensive review articles on "The Dynamics of Ocean Currents" and "The Properties of Sea Water", in the first volume of The Sea - I remember reading them with avid concentration when I was a graduate student.

From 1963 until his retirement in 1992, Nick Fofonoff was a senior scientist at the Woods Hole Oceanographic Institution. At Woods Hole, Nick continued his theoretical studies in physical oceanography, but also became a leader in the development of mooring technology and reliable current measuring systems. He played an important role in the planning and implementation of the seminal MODE program, its successor POLYMODE, and eventually of the World Ocean Circulation Experiment, for which he acted as director of the International Project Office from 1991-93. Jointly with fellow Canadian Lynn Lewis, Nick took the lead in the development and introduction of the now-standard Practical Salinity Scale.

Nick Fofonoff's influence in the development of modern physical oceanography has been considerable. His meticulous approach, based on solid physical understanding, set an example for many who have followed in his footsteps. In addition to the Stommel Award, Nick also received the American Geophysical Union's Ocean Science Award in 1990. Perhaps it's time he received more recognition in his native land.

Paul LeBlond,
Galiano Island, B.C.
December 29, 1998.

"La Femme Boutique" forecasts a cold 1998/99 winter for Winnipeg residents!

I am sending this photograph following the urging of Dr. M.L. Khandekar who considered the advertising very clever. Obviously the person in charge of advertising at "La Femme Boutique" has some understanding of the major climatic forcing function which determines winter temperatures over the Canadian prairies. The sign had been posted during the summer months of 1998. The photograph shown below was taken by Jeff Babb and me in August of 1998.

It is now becoming well known that a major driver of mild and cold winters over the Canadian Prairies is east equatorial Pacific sea surface temperatures. When the sea surface temperatures in the east equatorial Pacific are warmer than normal (El Niño) the Canadian prairies tend to be warmer than normal with less than normal precipitation during December through February. When the sea surface temperatures are colder than normal (La Niña) the Canadian prairies tend to be colder than normal with greater than normal precipitation from December through February. El Niño/La Niña shifts the temperature distribution over the Canadian prairies in the winter months. An American study concluded this twelve years ago (Ropelewski, C.F. and M.S. Alpert, 1987). A Canadian study substantiated this with over ninety years of data (Shabbar, A. and M.L. Khandekar, 1990).

Ray Garnett,
Winnipeg, Manitoba.

References:

1) Shabbar, A. and M.L. Khandekar (1990). *The Impact of El Niño-Southern Oscillation on the Temperature Field over Canada*, Atmosphere-Ocean, Vol.34, No.2, pp.401-416.

2) Ropelewski, C.F. and M.S. Halpert (1987). *Global and regional scale precipitation patterns associated with El Niño/Southern Oscillation*, Mon. Weather Rev. **115**: 1600-1620.

Alden Electronics

Alden Electronics, Inc. of Westborough, Massachusetts has appointed International Industries, Inc. of Annapolis, Maryland as their representative in portions of the Eastern United States for the Alden 9315CTP Thermal Imaging Recorder.

International Industries, Inc. will represent Alden in New York, New Jersey, Delaware, Maryland, Virginia, East Virginia, North Carolina, South Carolina, Pennsylvania, Ohio, Kentucky, Tennessee, Puerto Rico and the Cayman Islands.

International Industries, Inc. has over 30 years of experience in the Marine, Hydrographic, Oceanographic and Nuclear industries. An associated company, RentMar, Inc., provides rental services of hydrographic and oceanographic equipment. Contact information for International Industries is:

222 Severn Ave. Annapolis, MD 21403
Tel: (410) 990-0566; Fax: (410) 990-0569
URL: www.intnlind.com

The Alden 9315CTP Thermal Recorder produces 256 shades of gray per pixel and 2,048 pixels per line for high-resolution, photographic quality images. For more information of the Alden 9315CTP Thermal Recorder, please contact Michael Demos at (800) 225-9492, extension 2258, or via e-mail at cmd@alden.com or visit the Alden web site at www.alden.com.

***Alden**Electronics*
P.O. Box 500 - 40 Washington Street
Westborough, MA 01581-0500 U.S.A.

Dernière heure!

Au moment d'aller sous presse nous venons d'apprendre le décès de Mohammed I. El-Sabh, chercheur en océanographie et professeur de renommée internationale. Décédé dans la soirée du 8 février 1999 à Rimouski à l'âge de 59 ans, il a largement contribué depuis les années 1970 à la mise sur pied des programmes d'enseignement gradué en océanographie et des activités connexes de recherche à l'Université du Québec à Rimouski. Il a été président fondateur de la Société internationale pour la prévention des catastrophes naturelles en plus de présider et de coprésider plusieurs conférences internationales dans les domaines marins et océanographiques. Plusieurs de ses activités de recherche ont eu pour objet l'élaboration de modèles mathématiques de déversement accidentel de pétrole dans le Saint-Laurent, dans le golfe arabo-persique et dans le golfe de Suez.

P.A. Bolduc,
Rédacteur, CMOS Bulletin SCMO

Réf: Le Soleil, 10 février 1999, page A4.

In Memoriam
Clifford Jackson Stead (1921 - 1998)

Cliff Stead was born in Toronto 12 January, 1921. He died at his home in Kanata, Ontario 6 December, 1998 at the age of 77. He has been a longtime member of CMOS.

He served in the Royal Canadian Air Force during World War II, was commissioned, earned his pilot's wings and flew Ansons out of Charlottetown PEI on anti-submarine patrols over the Gulf of St. Lawrence. Following release from the RCAF at the end of the War, he enrolled at the University of Toronto, graduating with a bachelor of applied science in aeronautical engineering. After working briefly in the aircraft industry, Cliff joined the Meteorological Branch of the Department of Transport and was a graduate of the 1950-51 University of Toronto MA program in meteorology.

In 1952, Cliff was posted to the Main Meteorological Office at Goose Bay Labrador where he provided aviation forecast and briefing services to military forces, especially those of the United States Air Force. In 1959, after an unusually long seven-year tour of duty at Goose Bay, Cliff was posted to Air Force headquarters in Ottawa where he helped organize weather services for the RCAF.

In the summer of 1967, Cliff was awarded a four-year Short Service Commission in the RCAF in the rank of Wing Commander (later Lieut Colonel) and was posted to Canadian Forces Base Lahr, Germany, as Senior Staff Officer Meteorology to 1 Canadian Air Group. This was undoubtedly the high point of his career. He returned to Canada in 1971 and, for the remainder of his career, worked in the Directorate of Meteorology and Oceanography at National Defence Headquarters in Ottawa. For several years prior to his retirement in December 1980, he very ably represented Canada as its Member of the Working Groups on Weather Plans and Weather Communications of the NATO Group on Military Oceanography.

Cliff possessed a tremendous knowledge of aircraft. This was put to good use as a volunteer at the Canadian Aviation Museum where for some years in his retirement he helped identify photographs in the Museum's archives.

Cliff is survived by Evelyn, his wife of 52 years, his daughter Noreen, and grandsons Christopher and Dale.

Dave Nowell,
CMOS Member
Ottawa Centre

CMOS-Tertia Hughes Memorial Fund Reminder

In the last issue of the CMOS Bulletin (Vol.26, No.6, p.167) we noted the tragic death of one of our young and highly successful colleagues, Tertia Hughes. As noted in that article, CMOS has established a memorial fund which will be used to attach a monetary award to the Annual CMOS graduate student prize. The CMOS Council have approved in principal the renaming of their annual CMOS prize to the: "Tertia Hughes Memorial Graduate Student Prize". Formal approval will need to occur at the next Annual General Meeting of CMOS which will be in Montréal this coming spring.

Tertia Mary Clemency Hughes
July 24, 1967 - November 23, 1998

We are sincerely grateful for the outpouring of support for this fund from the CMOS and international community. To date we have received more than $7,300 towards our target of between $10,000 and $20,000. Our goal is to make the first awards at the 2000 CMOS Congress to be held in Victoria, B.C.

Anyone wishing to contribute to this fund should send cheques payable to:

"CMOS-Tertia Hughes Memorial Fund"

to the official CMOS business address which is:

CMOS - SCMO
Suiite 112, McDonald Building
University of Ottawa
150 Louis-Pasteur Ave.
Ottawa. ON K1N 6N5

Tax receipts (CMOS is a registered charitable organization) will be issued before the end of February 99 (for the 1999 tax year).

Fonds commémoratif Tertia Hughes-SCMO Rappel

Dans le dernier numéro de CMOS Bulletin SCMO (Vol.26, No.6, p.167), nous vous avons fait part du décès tragique d'une de nos jeunes et très talentueuse collègue, Tertia Hughes. Comme nous le mentionnions dans cet article, la SCMO a mis en place un fonds commémoratif qui sera utilisé pour remettre une somme d'argent avec les prix annuels SCMO des étudiants diplômés. Le Conseil de la SCMO a approuvé en principe le changement de nom de leur prix annuel au suivant: "Prix annuel commémoratif des étudiants diplômés Tertia Hughes". L'approbation formelle devra se faire lors de la prochaine assemblée générale annuelle qui aura lieu à Montréal au printemps.

Nous apprécions grandement tout l'appui reçu pour ce fonds de la part de la communauté internationale et de la SCMO. À ce jour, nous avons reçu plus de 7 300 $ vers notre objectif qui se situe entre 10 000 $ et 20 000 $. Nous souhaitons pouvoir remettre les premiers prix au congrès de l'an 2000, qui se tiendra Victoria, C.-B.

Toute personne désirant contribuer à ce fonds doit envoyer son chèque libellé au

"Fonds commémoratif Tertia Hughes-SCMO"

à l'adresse du bureau d'affaires de la SCMO suivante:

SCMO - CMOS
Bureau 112, Immeuble McDonald
Université d'Ottawa
150 avenue Louis-Pasteur
Ottawa, ON K1N 6N5

Des reçus pour fins d'impôts (la SCMO est une oeuvre de bienfaisance enregistrée) seront émis avant la fin de février 1999 (pour l'année fiscale 1999).

International Conference on Monsoon and Hydrologic Cycle Kyongju, Korea 22 - 25 April 1998

Conference Summary
by Madhav L. Khandekar[1]

An international conference on Monsoon and Hydrologic Cycle was held at the historic town of Kyongju (about 300 km southeast of Seoul), KOREA from 22-25 April 1998. The conference was organized by the Korean Meteorological Society in co-operation with the American Meteorlogical Society (AMS), the Canadian Metorological and Oceanographic Society (CMOS), the Australian Meteorological Society, Chinese Meteorological Society, Meteorological Society of Japan and the Royal Meteorological Society. There were about 200 participants at the conference, out of which about 60 percent or more were from Korea, representing several national and regional Universities as well as various research groups of the Korean Meteorological Administration (KMA).

Among the foreign participants were researchers from Australia, China, Japan, India and the U.S.A. I was the only Canadian participant at the conference. Noteworthy among the foreign participants were Drs. J. Shukla and P. Webster (USA), Dr. T. Yasunari (Japan), Dr. B.N. Goswami (India) and octogenarian Prof. T.-C. Yeh, former student of Rossby at the University of Chicago in the mid-forties and regarded as the father of modern meteorology in China.

The opening session on International and domestic programs started with a couple of review papers, one by Paul Try (Director, International GEWEX Project Office, USA) on the overview of the GEWEX Monsoon related activities and the other by T. Yasunary (a leading expert on Asian Monsoon at the University of Tsukuba (Japan) on the status of the GEWEX Asian Monsoon Experiment (GAME) and related research activities in Japan.

Following Yasunari's paper, there were two presentations on regional Monsoon studies: a paper by D.Ye (China) discussed monsoon variability in China over several thousand years and considered the influence of large-scale features like the heat source of Tibetan Plateau on the Chinese Monsoon, and another paper by J.W.Kim (Korea) which discussed monsoon variability in Korea and analyzed the impact of the Baiu front in the south and of the Polar front in the north. The last paper of the opening session was given by R. Anthes (USA) who presented an overview on the COSMIC Project which involves the GPS (Global Positioning System) / MET program and uses the radio occultation technique to determine ionospheric and neutral atmospheric refractivity.

Following the opening session there were three overview papers: P. Webster (a well-known Monsoon expert from University of Colorado, USA) discussed the GOALS (Global Ocean Atmosphere Land Study) Project and plans for the study of heat sources and sinks associated with Asia and the Americas, the principal focus of this project being the Asian-Australasian Monsoon system; J.Shukla (a noted Monsoon modeler at the Centre for Ocean-Land-Atmosphere Studies, USA) discussed the predictability of seasonal averages over the Indian Monsoon region and discussed weak and strong Monsoon years based on daily rainfall analysis; K.-M. (Bill) Lau (Head of the Climate and Monsoon Modeling Group at NASA, USA) presented a climate system approach to studies of the Asian summer Monsoon. Lau considered the Asian Monsoon as comprised of three subsystems, southeast Asian, south Asian and east Asian and discussed a new index developed to identify each of the three subsystems. Lau further considered the impact of large-scale forcings arising from SST (Sea Surface Temperature) anomalies, land surface processes and internal dynamics on the three subsystems and on their inter-relationships.

The afternoon session on ENSO and Monsoon had five papers: a paper by I.-S.Kang (Korea) on the modeling adjustment process between basin-wide heat content and SST forcing in the equatorial Pacific, a paper by J.S. Godfrey (Australia) on modeling of SST anomalies in the equatorial Pacific using an ocean general circulation model, a presentation by J. McCreary (Nova University, USA) on the application of a 4.5-layer ocean model over the Indian Ocean to simulate water movement in the Bay of Bengal in the presence of (the Ganges) river run-off, a paper by B.Wang (University of Hawaii, USA) on the role of western north Pacific winds on thermocline adjustment and ENSO phase transition and the fifth presentation by Jau-Ming Chen (Taiwan) on the relationship between ENSO and Asian summer Monsoon using an EOF (Empirical Orthogonal Function) analysis.

The final session on the first day was on Monsoon Variability where five papers were presented: P. Webster (USA) presented a comprehensive analysis on intraseasonal and interannual variability of the Asian-Australasian Monsoon, emphasizing the importance of the intraseasonal variability; B.N. Goswami (Indian Institute of Science, Bangalore, India) presented a broad-scale circulation index for interannual variability of the Indian summer Monsoon (Goswami's Monsoon index had an interesting similarity with Bill Lau's index for the study of Asian summer Monsoon); J.McBride (Australia) presented a paper on the impact of the Southern Oscillation (SO) on interannual variability of the Indonesian Monsoon, the dry season (beginning around April-May) rainfall being strongly

[1]Senior Consulting Meteorologist
Baird & Associates, Ottawa, ON
E-mail: madhavk@shaw.wave.ca

correlated with the SO index while the wet season (beginning around October-November) rainfall not at all; Joong-Bae Ahn (Korea) presented a simple moist atmosphere model for simulating intraseasonal and interannual oscillations over the eastern and western regions of the tropical Pacific. The final paper of the day was presented by S.D. Hahn (Korea) on long-term variability of unusual precipitation events in Seoul, Korea based on 227 years (1771-1997) of data.

The second day of the conference had three sessions of paper presentations and one poster session. In the first session on Large-scale Modeling, there were papers on regional, continental as well as global-scale modeling of Monsoon circulation. Of particular interest were papers by Y. Sud (NASA, USA) on modeling the influence of cloud microphysical parameterization and snow hydrology on Monsoon circulation, and by Min Dong (China) on modeling the influence of Tibetan snow cover on the general circulation of the east Asian Monsoon. In the session on Mesoscale Modeling, K. Ninomia (Japan) presented an observational study on the multi-scale features of the Baiu front, T.-Y. Lee (Korea) presented a numerical modeling study of heavy rainfall associated with the Changma front ('Changma' being identified with the wet summer Monsoon period in Korea) and R. Johnson(University of Colorado, USA) presented an observational study on the trimodal distribution of tropical clouds. In the session on Process Studies, L. Mahrt (Oregon State University, USA) presented a comprehensive paper on the formulation of surface fluxes in numerical simulations; a paper on the modeling of air-sea interaction in the Indian Ocean and its impact on the Indian Monsoon was presented by R. Murtugudde (University of Maryland, USA), and Goswami (India) presented an interesting modeling study to explore the genesis and structure of the tropospheric Quasi-Biennial Oscillation (QBO). In the poster session, there were several interesting papers, primarily by young researchers affiliated with various universities in Korea; noteworthy among the poster papers: Ailikun and Yasunari (Japan) on two indices of Asian summer Monsoon variability, J.-K.Kim et al (Seoul National University, Korea) on east Asian summer Monsoon simulation by the Seoul National University General Cirulation model and B.-C.Choi (KMA, Korea) on a statistical analysis of the relationship between Eurasian snow cover and summer Monsoon rainfall in south Korea.

The third day of the conference started with a session on Satellites in which a comprehensive paper on TRMM (Tropical Rainfall Measuring Mission) was presented by E. Smith (Florida State University, USA); TRMM is the first satellite (launched by Japan's Tanegashima Space Centre) dedicated to the measurement of the Earth's precipitation. The satellite will also be able to obtain the latent heating structure associated with the time-space distribution of precipitation and thus be a useful diagnostic tool for the study of the tropical Monsoon. Among the other papers in the Satellite session was a paper by H.-S. Chung (KMA, Korea) on estimating total precipitable water during the passage of the Monsoon Front (Changmas) over Korea using TVOS observations from the NOAA satellite. The next session on Regional Monsoon (East Asia) had several papers on east Asian and Korean Monsoon presented primarily by researchers from Korea and China. The following session on Regional Monsoon (Southeast Asia) had four papers most of them on studies relating summer Monsoon activities of the South China Sea; the papers were presented by participants from China and USA. The last presentation session of the day was on Regional Monsoon (India and South Asia) with four papers; S. Schubert (NASA, USA) presented a paper on modeling the development and onset of the Asian summer Monsoon with particular reference to the Indian subcontinent. I presented a paper on the impact of large-scale atmospheric circulations and anomalies on the Indian Monsoon droughts and floods; in my paper, I presented a simple conceptual model linking large-scale feaures like ENSO, Eurasian snow cover and tropical stratospheric QBO to the droughts and floods in the Indian Monsoon. D.-X. Wang (China) presented a paper on the oceanic thermal variability at the interannual time scale in the tropical Indian Ocean, while the last presentation of the day was by Murtugudde (USA) on air-sea interaction in the southern tropical Indian Ocean and its relation to interannual variability of the Indian Monsoon. There was a second poster session which displayed several papers on studies relating topics in meteorology and climatology of the Korean Peninsula and vicinity; the authors of these poster papers were affiliated with various Universities in Korea and with the KMA.

There were only two sessions on the last day of the conference; the first session was on Regional Monsoon (Other Regions) which included papers on topics like mid-summer drought over Mexico and Central America, predictability of North American warm season precipitation regime and flood analysis in the Chao Phraya River in Thailand. The last session of the conference was on Environmental Issues which included papers ranging in topics from simulation of anomalous rainfall episodes using a regional climate model to a statistical analysis of one-minute rain rate over the Korean Peninsula; the authors of these papers were mostly from Korea. In the afternoon, a trip to the local historical sites was organized.

The conference was in general well attended and was very well organized. All the members of the Organizing Committee were very friendly and extended their warm hospitality during my stay in Korea. A 345-page Preprint Volume containing all papers was ditributed at the conference and a copy of the same is available at Environment Canada's Downview library for further reference.

CLIMAR 99

Sheraton Wall Centre
Vancouver, B.C. Canada
8 - 15 September 1999

WMO Workshop on Advances in Marine Climatology

Background

The WMO Commission for Marine Meteorology (CMM) at its ninth session (Geneva, October 1984) agreed on the value of preparing a publication which would provide comprehensive documentation of the knowledge and techniques already in use by a number of Meteorological Services in the processing of marine meteorological data and, at the same time, describe in detail the diverse applications of such data in the service of the marine user community. The Commission's recommendation resulted in the publication, in 1995, of the WMO *Guide to the Applications of Marine Climatology*.

During its last session (Havana, March 1997), the Commission agreed with the proposal of its Working Group on Marine Climatology to update the Guide which should have now two parts: a static part expected to remain valid over a long time-frame, and a dynamic part covering issues such as new technologies and climate change. It further agreed that a workshop, to be held in 1999, should provide the input for the dynamic part.

During the same period, there has been a significant amount of research carried out by national agencies in a number of Member countries. Initiatives such as the Comprehensive Ocean-Atmosphere Data Set (COADS) under which two specialized events have been held, the "COADS Wind Workshop" (Kiel, Germany, May 1994) and the workshop on "Historical Marine Surface Data and Metadata" (Toledo, Spain, September 1997), are thought to be of particular importance as a contribution to the preparation of the new version of the Guide.

The Workshop is being held as a merged effort and will therefore also include contributions for COADS, particularly to cover "search for marine data on the Southern Hemisphere sparse data areas", "quality control and homogeneity" and "winds".

Objectives

The objectives of the Workshop are:

1) To receive appropriate input for the dynamic part of the new version of the WMO *Guide to the Applications of Marine Climatology*, with particular emphasis on new technologies;

2) To review the requirements of users for new marine climate products and enhanced climate information;

3) To provide guidance and technical support for those national Meteorological Services with responsibilities under the Marine Climatological Scheme (MCSS);

4) To make a further contribution to the data and metadata of COADS.

Participation

Participation is invited and anticipated from a wide range of professionals involved in the fields of applications of climatology, particularly marine climatology, climatological data archival and retrieval, climatological modelling, climate researchers, experts with responsibilities in the MCSS and marine climatic data users.

Organization

The Workshop is being organized jointly by the World Meteorological Organization, Environment Canada and the COADS programme of the National Oceanic and Atmospheric Administration (NOAA). The Workshop is also being co-sponsored by NOAA's Office of Global Programs (OGP) and its Environment Services Data and Information Management (ESDIM) program.

Venue

The Workshop will take place at the Sheraton Wall Centre Hotel, Vancouver, Canada. The hotel is located about three blocks away from the action of Robson Street. Vancouver is a world-class gateway city set amidst a majestic backdrop of mountains and sea. A block of rooms has been reserved for participants and the rate very conveniently negotiated to C$ 170 (approximately US$ 110) single or double occupancy. A hotel reservation form for the Sheraton is available upon demand.

Structure

The Workshop, which will take place in English only, is structured with an opening ceremony and session, followed by ten sessions (from the afternoon of Wednesday, 8 September 1999 to the morning of Wednesday, 15 September 1999), and ending with a discussion and closing session. The sessions will include both invited and contributed papers. Poster sessions will be organized if required. A Workshop Preprint volume of extended abstracts will be available. Invited papers as well as selected contributed papers will be considered for publication as the dynamic part of the WMO *Guide to the Applications of Marine Climatology*.

Workshop Programme

1. Characteristics of data from in situ observing platforms
Winds, waves and sea-surface temperature (SST) data are of primary interest.

Buoys;
Voluntary Observing Ships (including oil rigs);
Fishing fleet; Intercomparisons.

2. Development of blended satellite and in situ databases
Winds and waves; Precipitation;
SST; Humidity (flux).

3. Metadata and data quality
COADS quality control issues;
Analysis of WMO-47 data;
Use of WMO-47 data in climatological analysis;
Buoy metadata.

4. Bias adjustment in climate data
Winds; SST; Other parameters.

5. Reanalysis
Data assimilation techniques in reanalysis;
Intercomparison or evaluation of reanalysis fields (marine); Impact of satellite information on reanalysis data quality; potential bias.

6. Use of new marine climate products
Reanalysis databases; Satellite databases;
World Ocean Circulation Experiment (WOCE) and Global Ocean Observing System (GOOS) data sets.

7. User requirements for (enhanced, improved) climate information
Offshore, e.g. oil and gas industry; Fisheries;
Coastal zone management; Insurance.

8. Climate variability and change
Interannual - decadal; Teleconnections;
Century scale - climate change detection.

9. Database enhancements
COADS/United Kingdom Met Office blended database; Adding new historical data sets.

10. Climate predictions

Workshop papers: invited and contributed

Invited speakers are being identified for each session. All invited speakers will be notified in April 1999. Contributed presentations will be accepted subject to approval of the one-page abstract submitted to the Organizing Committee (see below). A maximum of about 30 contributed papers can be accommodated in the programme: papers in excess of this number may be placed in poster sessions. Authors of contributed presentations are totally responsible for their own travel costs.

All authors should submit an informal one-page abstract by 31 March 1999, preferably by e-mail, but alternatively by fax or paper mail. The purpose of these abstracts' submission is the selection of the papers that will comprise the final programme, the determination of those who will be designated as invited speakers, the size of the programme and whether a poster session will be required. The second Workshop submission will be an extended abstract, due on 1 August 1999. Its length should be 5-15 pages for invited papers and 5-10 pages for contributed papers. Extended abstracts will be printed in a Preprint volume, to be available at the beginning of the Workshop and authors should provide them in the format used by the American Meteorological Society (AMS) for its Conference Preprint volumes. Graphics, figures and photographs, if included, should be made available in electronic form (JPEG format). Authors will be responsible for adhering to these formats. Extended abstracts, combined with the summaries prepared by the session rapporteurs, will also be published in WMO Marine Meteorology and Related Oceanographic Activities (MMROA) reports series and placed on the WMO Web page.

A third level of submission's usage is also planned and would be mandatory for invited speakers and optional for contributed papers. These papers would be subject to peer review. Following peer review, the authors would submit a final version, in electronic form, to the Organizing Committee. This would then undergo technical editing, and be later published by WMO as the dynamic part of the *Guide to the Applications of Marine Climatology* (about 31 March 2000). Selected papers would also be available on a number of relevant Web pages (e.g. Environment Canada, COADS, NCDC).

Authors of invited papers may apply for reimbursement of their travel costs (APEX airfare) and other expenses such as hotel, lump sum for meals and incidentals. However, no honorariums will be paid for their attendance.

Organizing Committee

- Mr. Val Swail, Chairman
Environment Canada; Downsview, Ontario, Canada
Fax: (416) 739-5700; e-mail: Val.Swail@ec.gc.ca

- Dr. Henry F. Diaz
Climate Diagnostic Center; Boulder, CO, USA
Fax: (303) 497-7013; e-mail: hfd@cdc.noaa.gov

- Mr. Joe D. Elms
National Climatic Data Center
Asheville, NC, USA
Fax: (828) 271-4328; jelms@ncdc.noaa.gov

- Mr. Fernando Guzmán
Ocean Affairs Division
WMO, Geneva, Switzerland
Fax: 4122 733 02 42; e-mail: fguzman@www.wmo.ch

Volume 26 at a glance / Coup d'oeil rapide sur le volume 26

Articles and Short Notes / Articles et notes brèves

Workshop Reports / Rapports d'atelier

Montréal 1999 Montréal

Mot de Pierre Dubreuil, président
Centre de Montréal
Société canadienne de météorologie et d'océanographie (SCMO)

Bonjour,

C'est un immense plaisir pour moi de vous inviter au 33e congrès de la SCMO, qui se déroulera à Montréal, du 31 mai au 4 juin 1999.

Nous avons choisi comme thème la prévision environnementale, domaine en pleine effervescence depuis quelques années. Non seulement la prévision environnementale comprend-elle diverses composantes de l'océanographie et de la météorologie, mais elle les relie entre elles davantage. C'est aussi l'une des grandes forces de la communauté scientifique locale.

En effet, Montréal constitue un pôle très actif dans les domaines de la météorologie, de l'océanographie et de l'environnement. Deux de nos quatre universités, McGill et l'Université du Québec à Montréal (UQÀM), offrent des programmes de 1er cycle, de 2e cycle et de 3e cycle dans ces domaines. Environnement Canada y a de nombreux bureaux importants. Mentionnons le quartier général régional pour la météorologie et le Bureau de services météorologiques pour le sud du Québec; le Centre météorologique canadien, responsable de la prévision numérique pan-canadienne et du Centre de super-informatique; une partie importante de la Direction de recherche en météorologie, incluant RPN (Recherche en prévision numérique). Également à Montréal, le CERCA (Centre de recherche en calcul appliqué) applique des méthodes numériques avancées à divers domaines, dont les simulations environnementales. En somme, Montréal est l'une des grandes villes de recherche et de prévisions environnementales au pays et dans le monde.

En plus du thème principal, le Congrès touchera à l'ensemble des domaines et aspects de l'océanographie et de la météorologie. Je suis assuré que les chercheurs, professeurs et étudiants de même que l'ensemble des météorologues et océanographes seront intéressés par les sujets abordés lors de ce congrès, et stimulés par les échanges scientifiques avec leurs pairs. Je vous invite à naviguer plus à fond sur notre site (**http://www.cmc.ec.gc.ca/scmo99**) pour trouver plus de renseignements concernant le Congrès.

Pour vous-mêmes, ainsi que pour vos conjoints et votre famille s'ils vous accompagnent, Montréal et ses environs offrent une foule d'attraits touristiques, en particulier au mois de juin. N'hésitez pas à naviguer sur les sites suivants:

http://www.montrealcam.com/ **http://www.pagemontreal.qc.ca**
http://www.stcum.qc.ca
http://www.stcum.qc.ca/metro/images/c11.gif (carte du quartier Berri-UQAM).

Je vous souhaite donc la bienvenue et j'espère vous retrouver en grand nombre, le 31 mai prochain, à l'Université du Québec à Montréal (UQÀM) où se déroulera le congrès.

Sincèrement,

Pierre Dubreuil
Président, Centre de Montréal
Société canadienne de météorologie et d'océanographie

Montreal 1999 Montreal

A word from Pierre Dubreuil, Chairman
Montreal Centre
Canadian Meteorological and Oceanographic Society (CMOS)

Hello!

It gives me great pleasure to invite you to the 33rd annual Congress of the CMOS, which will be held in Montreal from May 31 to June 4, 1999.

The theme of this year's congress is environmental prediction, which has been a very dynamic field in the past few years. Not only does environmental prediction include various components of oceanography and meteorology, it creates even more links between the two disciplines. It is also one of the great strengths of our local scientific community.

Montreal is a very active centre in meteorology, oceanography and the environment. Two of our four universities, McGill and the University of Quebec at Montreal (UQÀM), have undergraduate, master's and doctorate programs in these fields. Environment Canada has a number of major offices here as well: regional meteorology headquarters and the weather services office for southern Quebec; the Canadian Meteorological Centre, which is in charge of Canada-wide numerical weather forecasting and the Supercomputer Centre; a large share of the Meteorological Research Branch, including RPN (Recherche en Prévision Numérique). Montreal is also home to CERCA (Centre for Research on Computation and its Applications), which applies advanced numerical methods to a variety of fields, including environmental simulations. In short, Montreal is one of the great cities for environmental research and prediction in Canada and around the world.

In addition to the main theme, the Congress will consider oceanography and meteorology as a whole and different aspects of these fields. I am convinced that researchers, professors and students as well as meteorologists and oceanographers will find the topics discussed at the congress interesting and that they will be stimulated by scientific debates with their peers. I encourage you to visit our Web site (**http://www.cmc.ec.gc.ca/cmos99**) for more information about the Congress.

Whether you are visiting on your own, or with your spouses and family, Montreal offers many tourist sights and events in the month of June. Browse the following sites to learn more:

http://www.montrealcam.com/ **http://www.pagemontreal.qc.ca**
http://www.stcum.qc.ca
http://www.stcum.qc.ca/metro/images/c11.gif (map around Berri-UQÀM).

I would like to welcome everyone to the Congress and hope to see many of you on May 31 at UQÀM.

Yours truly,

Pierre Dubreuil
Chairman, Montreal Centre
Canadian Meteorological and Oceanographic Society

CMOS Congress 1999 in Montréal
May 31 - June 4, 1999
Theme:
Environmental Prediction

Congrès 1999 de la SCMO à Montréal
31 mai au 4 juin 1999
Thème:
Prévisions environnementales

Student Travel Bursaries

Graduate students interested in attending the CMOS Congress in Montréal in May 1999, should consider submitting an application for a Congress Travel Bursary. Approximately $5,000 is allocated each year to support students up to a maximum of $500 each.

Bourses de voyage pour étudiants

Les étudiants de deuxième cycle intéressés à participer au congrès de la SCMO à Montréal en mai 1999 devraient songer à soumettre une demande de bourse à leur centre local de la SCMO (ou chapître). Environ 5 000$ sont alloués chaque année afin d'aider les étudiants pour un maximum de 500$ chacun.

Requirements:

1. The student or his/her supervisor must be a member of CMOS; and

2. The student must prepare, and have had accepted an abstract and paper for presentation at the Congress; or

3) Be the current recipient of a CMOS Graduate Student Prize; or

4) Be the current holder or awardee of a CMOS Scholarship.

Considerations:

Preference will be given to students who have not previously received a CMOS travel bursary and who are presenting a first-time paper.

Application Forms:

For more details about the CMOS Congress program, consult the CMOS web page at http:www.meds-sdmm.dfo-mpo.gc.ca/cmos.

Application forms must be submitted by April 1 of the current year to:

Office of the Executive Director
Canadian Meteorological and Oceanographic Society
Suite 112 - 150 Louis-Pasteur
Ottawa, ON K1N 6N5
Tel: (613) 990-0300
Fax: (613) 993-4658
e-mail: cmos@meds-sdmm.dfo-mpo.gc.ca

Exigences:

1. L'étudiant ou son superviseur doit être un membre de la SCMO; et

2. L'étudiant doit préparer, et s'être vu accepter, un résumé pour une présentation au Congrès; ou

3) Être récipiendaire du Prix de l'étudiant diplômé de la SCMo de cette année; ou

4) Être le récipiendaire actuel d'une bourse de la SCMO.

Considérations:

La préférence sera donnée aux étudiants n'ayant jamais reçu de bourse de voyage de la SCMO et qui présentent pour la première fois une communication.

Demandes de formulaire:

Pour obtenir des renseignements additionnels sur le programme du Congrès de la SCMO, consultez la page Web de la SCMO au http://www.meds.dfo.ca/cmos.

Les formulaires d'inscription doivent être reçus au plus tard le 1er avril de l'année en cours au:

Bureau du Directeur exécutif
Société canadienne de météorologie et d'océanographie
Bureau 112 - 150 avenue Louis-Pasteur
Ottawa, ON K1N 6N5
Tél: (613) 990-0300
Télécopieur: (613) 993-4658
courriel: cmos@meds-sdmm.dfo-mpo.gc.ca

(Note: L'emploi du masculin n'a pour but que d'alléger le texte.)

AIR CANADA

TRANSPORTEUR OFFICIEL

Air Canada a été désignée le transporteur officiel du 33e Congrès annuel de la Société canadienne de météorologie et d'océanographie (SCMO) qui aura lieu du 31 mai au 4 juin 1999, à l'Université du Québec à Montréal (UQÀM).

Appelez dès aujourd'hui Air Canada au 1-800-361-7585 ou votre agent de voyages et profitez des avantages suivants :

- Tarifs congrès spéciaux pour l'Amérique du Nord, les Antilles, les Bermudes et le Mexique;
- Économies appréciables grâce aux tarifs congrès spéciaux qu'Air Canada et Continental Airlines offrent sur leurs services communs;
- Possibilité d'utiliser des milles Aéroplan ou Mileage Plus pour tout vol d'Air Canada ou d'United Airlines, partout dans le monde;
- Tarifs préférentiels pour la location de voitures Avis, Budget ou Hertz;
- Jusqu'à 40 % de réduction sur les tarifs de classe hospitalité;
- 25% de réduction sur les tarifs de fret aérien.
- Pour les congressistes de l'étranger, offre du meilleur tarif disponible au moment des réservations.

Note: Certaines conditions peuvent s'appliquer.

En vous assurant que le numéro d'événement **CV994043** figure bien sur votre billet, peu importe le tarif payé, vous appuierez financièrement la SCMO. Nous vous en remercions.

AIR CANADA

OFFICIAL AIRLINE

Air Canada has been appointed the Official Airline of the 33rd Annual Congress of the Canadian Meteorological and Oceanographic Society (CMOS), to be held from 31 May to 4 June, 1999, at the Université du Québec à Montréal (UQÀM).

Call Air Canada at 1-800-361-7585 today or your travel agent, and take advantage of :

- Special convention rates for travel within North America, the Caribbean, Bermuda and Mexico.
- Substantial savings with Air Canada and Continental Airlines' joint Convention fares.
- Aeroplan or Mileage Plus miles that can be redeemed on any Air Canada or United Airlines route, worldwide.
- Preferred rates on Avis, Budget and Hertz car rental.
- Savings up to 40 % on the regular Economy Class Fares.
- 25% savings onair cargo rates.
- Overseas passengers will be offered the best available fare.

Note : Certain conditions may apply.

By ensuring your Event Number **CV994043** appears on your ticket, regardless of the fare purchased, you will help support CMOS financially. We thank you.

AIR CANADA

Proposed Amendments to CMOS By-Law

There are several proposed minor amendments to the By-Laws for consideration at the 1999 Annual General Meeting. The first amendment reflects a name change to a prize; the second change is to cover a proposed new name for a graduate student prize; and the third is intended to reflect the manner in which travel expenditures are approved by Council.

Amendment I

Council moves that in Appendix I, Prizes and Awards, paragraph e) the title be amended to read "The Rube Homstein Medal in Operational Meteorology" in lieu of "the Rube Hornstein Prize in Operational Meteorology", and similarly the name of the prize in the text of paragraph e).

Amendment II

Council moves that one of the Graduate Student Prizes be named the "Tertia MC Hughes Memorial Graduate Student Prize".

Amendment III

Council also moves that in Appendix III, Committees and Editorial Boards, subsection "Meetings", paragraph 2, be amended to read:

"Travel expenses for attendance at such meetings may be paid by CMOS if prior approval for paid attendance is obtained by Council" in lieu of: "Travel expenses for attendance at such meetings may be paid by CMOS if prior approval for paid attendance is obtained by the Vice-President".

Proposed by:
CMOS Executive Council.

Modifications proposées aux Règlements de la SCMO

Plusieurs propositions de modifications aux règlements doivent être étudiées lors de l'assemblée générale annuelle 1999. La première modification concerne le changement de nom d'un prix, la seconde le changement proposé du nom des prix des étudiants diplômés et la troisième la façon dont les frais de déplacement sont approuvés par le Conseil.

Modification I

Le Conseil propose que le titre de l'Appendice I, Prix et récompenses, paragraphe e) soit modifié à "La médaille Rube Homstein en météorologie opérationnelle" au lieu du "Prix de météorologie opérationnelle Rube Hornstein", et que la modification du nom du prix s'applique également au texte du paragraphe e).

Modification II

Le Conseil propose que le nom des prix pour étudiants diplômés soit changé à "Prix commémoratifs pour étudiants diplômés Tertia MC Hughes".

Modification III

Le Conseil propose également que le paragraphe 2 de l'Appendice III, Comités et Conseils de rédaction, sous-section "Réunions" soit modifié par le texte suivant :

"Les membres présents à ces réunions ne pourront obtenir le remboursement de leurs frais de déplacement que s'ils ont préalablement obtenu l'autorisation du Conseil à cette fin" au lieu de "Les membres présents à ces réunions ne pourront obtenir le remboursement de leurs frais de déplacement que s'ils ont préalablement obtenu l'autorisation du vice-président à cette fin".

Proposé par:
Conseil exécutif de la SCMO.

CMOS-ACCREDITED CONSULTANTS
EXPERTS-CONSEILS ACCRÉDITÉS de la SCMO

Mory Hirt

Applied Aviation & Operational Meteorology

Meteorology and Environmental Planning
401 Bently Street, Unit 4
Markham, Ontario, L3R 9T2 Canada
Tel: (416) 477-4120
Telex: 06-966599 (MEP MKHM)

Richard J. Kolomeychuk

Applied Climatology and Meteorology
Hydrometeorology, Instrumentation

Envirometrex Corporation
14A Hazelton Ave., Suite 302
Toronto, Ontario, M5R 2E2 Canada
Tel: (416) 928-0917 Fax: (416) 928-0714
e-mail: kolomey@ibm.net

Tom B. Low, Ph.D., P.Eng

Research and Development Meteorology

KelResearch Corporation
850-A Alness Street, Suite 9
Downsview, Ontario, M3J 2H5 Canada
Tel: (416) 736-0521 Fax: (416) 661-7171
E-mail: kel@nexus.yorku.ca

Ian J. Miller, M.Sc.

Marine Meteorology and Climatology
Applied Meteorology, Operational Meteorology
Broadcast Meteorology

Météomédia / The Weather Network
1755, boul. René-Levesque Est, Suite 251
Montréal, Québec, H2K 4P6 Canada
Tel: (514) 597-1700 Fax: (514) 597-1591

Douw G. Steyn

Air Pollution Meteorology
Boundary Layer & Meso-Scale Meteorology

4064 West 19th Avenue
Vancouver, British Columbia, V6S 1E3 Canada
Tel: (604) 822-6407
Home: (604) 222-1266

Bill Thompson

Flood Warning, Marine Applications
Integrated Monitoring and Prediction Systems
International Aid and Development Projects

Atmospheric Environmental Consultants
112 Varsity Green Bay NW
Calgary, Alberta, T3B 3A7 Canada
Tel / Fax: (403) 286-6215
E-mail: thompsow@cadvision.com

Imagine your own business card in this empty space.

Call us now!

Imaginez votre propre carte d'affaire dans cet espace libre.

Appelez-nous immédiatement!

CANADIAN METEOROLOGICAL AND OCEANOGRAPHIC SOCIETY

LA SOCIÉTÉ CANADIENNE DE MÉTÉOROLOGIE ET D'OCÉANOGRAPHIE

112-150 Louis Pasteur, Ottawa, ON K1N 6N5
Tel - Tél: (613) 562-5616 Fax - Téléc: (613) 562-5615
E-mail - Couriel: cap@physics.uottawa.ca
Web: www.meds-sdmm.dfo-mpo.gc.ca/cmos/

MEMBERSHIP APPLICATION / RENEWAL FORM
DEMANDE D'ADHÉSION / RENOUVELLEMENT

☐ NEW APPLICATION / NOUVELLE DEMANDE ☐ RENEWAL / RENOUVELLEMENT

MEMBER SINCE / MEMBRE DUPUIS **MEMBERSHIP EXPIRES / ADHÉSION SE TERMINE**

TITLE / TITRE ☐ DR. / DR. ☐ MR. / M. ☐ MS / MME ☐ OTHER / AUTRE

MAILING ADDRESS / ADRESSE POSTALE ☐ RESIDENCE / RÉSIDENCE ☐ BUSINESS / BUREAU

POSTAL CODE / CODE POSTAL

TEL (B) FAX (B)

TEL (R) FAX (R)

E-MAIL - COURIEL

HOMEPAGE - PAGE D'ACCUEIL

LANGUAGE PREFERENCE / LANGUE PRÉFÉRÉE ☐ ENGLISH ☐ FRANÇAIS

OPTIONAL / FACULTATIF ☐ MALE / MASC. ☐ FEMALE / FÉMININ D.O.B. / D.D.N. (Y-A * M-M * D-J)

AREA OF WORK / SECTEUR D'EMPLOI ☐ INDUSTRY / INDUSTRIE ☐ GOV'T / GOUV. ☐ UNIV. / UNIV. ☐ RES. INST. / INST. RES. ☐ OTHER / AUTRE

MAIN INTEREST / INTÉRÊT PRINCIPAL ☐ METEOROLOGY / MÉTÉOROLOGIE ☐ OCEANOGRAPHY / OCÉANOGRAPHIE

SPECIAL INTEREST / INTÉRÊTS SPÉCIAUX

☐ HYDROLOGY / HYDROLOGIE
☐ FISHERIES OCEANOGRAPHY / OCÉANOGRAPHIE DES PÊCHES
☐ AGRICULTURE & FOREST / AGRICULTURE ET FORÊT
☐ MESOSCALE METEOROLOGY / MÉTÉOROLOGIE DE L'ÉCHELLE MÉSO
☐ FLOATING ICE / GLACES FLOTTANTES
☐ GLOBAL CHANGE / CHANGEMENT GLOBAL
☐ OPERATIONAL METEOROLOGY / MÉTÉOROLOGIE D'EXPLOITATION
☐ OTHER / AUTRE

LOCAL CENTRE OR CHAPTER / CENTRE OU SECTION LOCALE ☐ INSERT CODE / INSÉRER LE CODE

VIS	VANCOUVER ISLAND CENTRE	MTL	CENTRE DE MONTRÉAL
BCM	B.C. MAINLAND CENTRE	QUE	CENTRE DE QUÉBEC
KEL	KELOWNA CHAPTER	RIM	CENTRE DE RIMOUSKI
ALT	ALBERTA CENTRE	HFX	HALIFAX CENTRE
SSK	SASKATCHEWAN CENTRE	NFD	NEWFOUNDLAND CENTRE
WIN	WINNIPEG CENTRE	NBK	NEWBRUNSWICK CHAPTER
TOR	TORONTO CENTRE	INT	INTERNATIONAL & USA
OTT	OTTAWA CENTRE		

☐ DO NOT PUBLISH MY NAME IN DIRECTORY / NE PAS PUBLIER MON NOM DANS LE RÉPERTOIRE

☐ DO NOT CIRCULATE MY NAME OUTSIDE CMOS / NE PAS FOURNIER MON NOM À D'AUTRES ORGANISMES

FOR OFFICE USE ONLY - À L'USAGE DU SECRÉTARIAT

*	√	MEMBERSHIP FEES - FRAIS D'ADHÉSION	RATE / TARIF	REMITTANCE / REMISE
		REGULAR - RÉGULIER	45.00	
		STUDENT - ÉTUDIANT *	20.00	
		CORPORATE - CORPORATION *	225.00	
		(FIRMS - CORPORATIONS, INSTITUTIONS)		
		SUSTAINING - DE SOUTIEN *	170.00	
		(INDIVIDUALS ONLY - PARTICULIERS)		
		RETIRED - RETRAITÉ	30.00	
		* INCLUDES ALL PUBLICATIONS - DONNE DROIT À TOUTES PUBLICATIONS		

*	√	MEMBER'S PUBLICATIONS FEES / FRAIS DES PUBLICATIONS - MEMBRES		
		ATMOSPHERE - OCEAN	35.00	
		CMOS BULLETIN SCMO (INCL.)	GRATIS	
		PROGRAM & ABSTRACTS (ON REQUEST) / PROGRAMME ET RÉSUMÉS (SUR DEMANDE)	GRATIS	
		SUB TOTAL - SOUS TOTAL		

*	√	VOLUNTARY CONTRIBUTIONS * / CONTRIBUTION VOLONTAIRES *		
		CMOS SCHOLARSHIP - BOURSE SCMO		
		DEVELOPMENT FUND - FONDS DE DÉVELOPPEMENT		
		RUBE HORNSTEIN FUND - FONDS DE RUBE HORNSTEIN		
		J.P. TULLY FUND - FONDS DE J.P. TULLY		
		* TAX DEDUCTIBLE - DONNE DROIT À DÉGRÈVEMENTS D'IMPÔT		

TOTAL NOTE GST & HST EXEMPT - EXEMPT DE TPS ET TVH $

I WISH TO PAY BY: / JE DÉSIRE PAYER PAR: ☐ CHEQUE / CHÈQUE ☐ MONEY ORDER / MANDAT

OR / OU CHARGE MY / CARTE ☐ MASTERCARD ☐ VISA

CARD N° / NO DE CARTE

EXPIRY DATE - DATE EXP.

X _____ SIGNATURE

If this is a student application please provide the name and signature of one of your professors. For records only; please indicate the institution and year studies will be completed and degree anticipated.

Si vous désirez devenir membre étudiant, S.V.P. obtenir le nom et la signature d'un de vos professeurs. Pour nos dossiers seulement; S.V.P. indiquez le nom de votre institution, l'année où vous finirez vos études et le diplôme attendu.

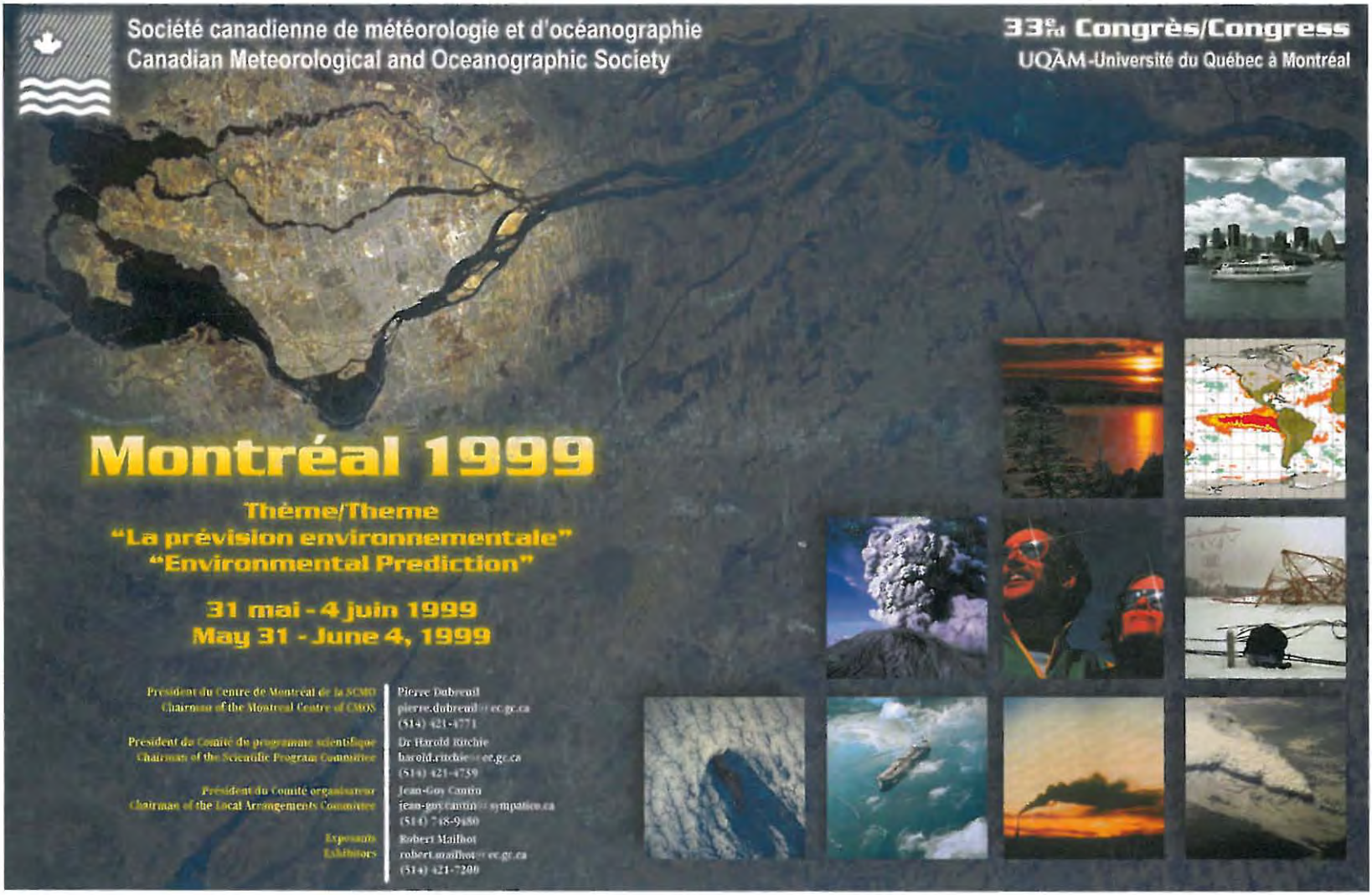
_____ X _____
PROFESSOR'S NAME - NOM D'UN PROFESSEUR SIGNATURE

_____ _____
YEAR - ANNÉE INSTITUTION

☐ BSc ☐ MSc ☐ PhD

X _____ _____
SIGNATURE OF APPLICANT - SIGNATURE DU DEMANDEUR DATE

SCMO 1999 CMOS 1999
Montréal



Bienvenue Welcome