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La Société canadienne de météorologie et d'océanographie

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CMOS Bulletin SCMO

"at the service of its members
au service de ses membres"

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Cover page: 45-m instrumented scaffolding tower used at Borden for long-term measurements started in 1995 with the goal to understand the sequestration capability of the Borden forest and how climatic perturbations such as drought can impact forest carbon uptake. To understand the inter-annual and inter-seasonal variability of carbon uptake, a plethora of ancillary measurements are being taken including the fluxes of water vapor, sensible heat and momentum. Photograph courtesy of Environment Canada. To learn more, please read the article on page 9.

Page couverture: Tour en échafaudage instrumentée de 45 mètres utilisée à Borden pour les mesures à long terme initiées en 1995 dans le but de comprendre le pouvoir de séquestration de la forêt de Borden et l'effet que les perturbations climatiques, telles que la sécheresse, peuvent avoir sur la capture de carbone par la forêt. Afin de comprendre la variabilité inter-annuelle et inter-saisonnière de la capture de carbone, on fait une abondance de mesures subordonnées, incluant le flux de vapeur d'eau, de chaleur sensible et de momentum. Photographie, courtoisie de Environnement Canada. Pour en apprendre plus, voir l'article en page 9.

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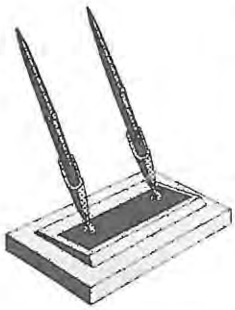
....from the President's Desk



The Natural Sciences and Engineering Research Council (NSERC) is the principal government funding agency for academic research in the "natural" sciences and engineering in Canada. Within NSERC, the granting process is managed by a large number of disciplinary Grant Selection Committees (GSCs), each of which has a certain share of the total pot. Most of the money for research in meteorology and oceanography goes through GSC 09, Environmental Earth Sciences. Every four years or so a percentage of each Committee's share goes back into the pot for reallocation. In the last such exercise in 1998, each Committee gave up 10% of its funds for reallocation. For purposes of the reallocation exercise, GSC 09 and GSC 08, Solid Earth Sciences, were lumped together. In 1998 Solid and Environmental Earth Sciences lost badly in the competition with other disciplines for a share of the reallocation pot, getting back less than 60% of the funds contributed. Both groups also lost in the 1994 exercise. The next one will be in 2002. Needless to say, the earth sciences community is determined to do better in the next round.

In commenting on the submission from GSC 08/09, the 1998 Reallocation Committee said that they agreed with the verdict of the external referees to the effect that "*The vision presented ...... failed to provide a compelling view of emerging areas and priorities for the future.*" They went on to say that "*Major issues like global change were barely mentioned. .... The environmental sciences field is indeed an emerging one, but a strong case was not made for it in the submission. ...... The failure to provide a strong vision for the future for this area of science in comparison to other submissions limited the funds reallocated.*" These are strong words and they merit a lot of attention in preparing for the next round.

The Canadian Geoscience Council (CGC), an umbrella grouping of Canadian earth science societies, is working closely with the NSERC Liaison Committee for Earth Sciences. This latter committee was set up by academics in the earth sciences, at NSERC's urging, to prepare a vision for the future of the earth sciences in Canada to feed into the next reallocation exercise. CMOS is not a member of the CGC but we do have observer status and have sent a representative to several recent CGC meetings. It will be important for CMOS and concerned CMOS members to work closely with the CGC and with the Liaison Committee.

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Inside / En Bref

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Last summer CMOS wrote to NSERC with an offer to assist. Since then we have received contacts from both NSERC and the CGC. Prof. Richard Peltier now chairs the Liaison Committee, an appointment that should strengthen the position of the "fluid" earth science community. The CGC societies and others are holding a major meeting known as GeoCanada 2000 in Calgary at the end of May and beginning of June (http://www.geoscience.ca/geocanada2000.html). At that meeting there will be a special session on the visioning exercise, organised by CGC and by the Science Academy of the Royal Society of Canada. This session will draw upon the returns from an Internet-based questionnaire hosted by NSERC (http://nserc.xander.com/about.html). I hope that many of our CMOS members who are past, present or prospective NSERC grant holders have had a chance to complete it. The next major chance to input will be at GeoCanada 2000, but unfortunately these sessions are being held at precisely the same time as our CMOS Congress in Victoria (29 May-2 June). Nevertheless, some of you may be able to be there. In addition, NSERC has offered to have someone from the Liaison Committee make a presentation at the CMOS Congress. We will try to arrange a suitable vehicle for that, perhaps the session of the CMOS Science Committee. For more backgound material on these matters, the CGC web-site (http://www.geoscience.ca/) is a good place to start.

Ian D. Rutherford
President / Président
CMOS / SCMO

Motion of Amendment to the Constitution and By-Laws of CMOS

Proposition d'amendement à la Constitution et aux réglements de la SCMO

In an effort to broaden the scope and involvement of CMOS Committee Chairpersons, the Council of CMOS is proposing that chairpersons of committees appointed by Council be considered as Members of Council. This motion affects ARTICLE 4 - The Executive and Council and ARTICLE 16 - Committees, Editorial Boards and Working Groups.

Dans le but d'élargir le champ d'action et l'implication des présidents des comités de la SCMO, le Conseil de direction propose que les présidents des comités nommés par le Conseil soient considérés comme membres du Conseil. Cette proposition affecte l'ARTICLE 4 - Le bureau et le conseil d'administration et l'ARTICLE 16, Comités, conseils de rédaction, et groupes de travail.

ARTICLE 4 - The Executive and Council

The Executive of the Society consists of the President, the Vice-President, the Treasurer, the Corresponding Secretary, and the Recording Secretary. It also includes the Executive Director and the Director, CMOS Publications, who are ex-officio and without voting privileges. The Council of the Society consists of the Executive, the immediate Past President, the three Councillors-at-Large, the Chairpersons of the Centres/Chapters as well as the Chairpersons of the CMOS committees appointed by Council.

ARTICLE 4 - Le bureau et le conseil d'administration

Le bureau d'administration de la Société se compose d'un président(e), d'un vice-président, d'un trésorier, d'un secrétaire-correspondant, et d'un secrétaire d'assemblée. Le bureau d'administration inclut le directeur exécutif et le directeur, publications SCMO, qui sont membres à titre d'office et sans privilège de vote. Le conseil d'administration de la Société se compose des membres du bureau d'administration, du président(e) sortant, des trois conseillers, et des présidents des Centres/Chapitres, ainsi que des présidents des comités nommés par le conseil d'administration.

BY-LAW 16 - Committees, Editorial Boards and Working Groups

a) The Committees appointed by the Council are: The Accreditation Committee, the Weathercaster Endorsement Committee, the Nominating Committee, the Prizes and Awards Committee, the Education Committees (Committee), the Private Sector Committee, the Scientific Committee, the Fellows Committee, and the Scholarship Committee whose Chairperson shall be the Vice-President of CMOS. Ad Hoc and other Committees may be appointed by the Council as required.

RÈGLEMENT 16 - Comités, conseils de rédaction, et groupes de travail

a) Le conseil d'administration désigne les comités suivants: le comité d'accréditation, le comité pour l'agrémentation de présentateurs météo, le comité des mise en candidature, le comité des prix et honneurs, les comités d'education (le comité d'éducation), le comité du secteur privé, le comité scientifique, le comité des Fellows, et le comité des bourses dont le président(e) sera le vice-président de la SCMO. Le conseil d'administration peut selon le besoin désigner d'autres comités et des comités spéciaux.

Next Issue - Prochain Numéro

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

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

Développement et implantation de nouvelles technologies de mesures du niveau d'eau pour les levés hydrographiques[1]

par Bernard Tessier[2], ing. et Daniel Langelier[2]

Summary

The Canadian Hydrographic Service (CHS), Laurentian Region, carries out annual 300 km long bathymetric surveys of the St. Lawrence River for use in controlling the nominal depth of the navigation channel. The current system for these surveys requires using tide staffs (graduated scales placed along wharfs) or tide gauges installed at specific locations as close as possible to the work sector. In both cases, the data are transmitted by radio to the hydrographer aboard the ship. In certain zones, it is necessary to use several tide staffs or tide gauges simultaneously; the data are then interpolated in order to establish the water level reduction. The on-board hydrographic interpolation of water level data utilizes an application called AutoMarée. For the sector between Montréal and Cap Gribane (downstream limit of the Traverse Nord), the CHS must use 60 to 70 tide staffs, which is no longer economical at present.

The installation of the permanent infrastructure of the Canadian Coast Guard's (CCG) DGPS network in Summer 1996, together with current technological facilities, has opened the possibility of using the On-the-fly (OTF) technique, a method for resolving GPS phase ambiguity in the kinematic positioning mode. When applied to bathymetric surveys of the St. Lawrence channel, the OTF approach would allow elimination of the tide staffs that are used for reducing the bathymetric soundings. In order to validate the results of the OTF method, an integrity system was also developed, based on a one-dimensional model of the St. Lawrence River.

CHS, CCG, the private sector and geomatics teaching institutions have been working together for a few years in order to implement DGPS-OTF technology for hydrographic surveys between Montréal and Ile-aux-Coudres. For planning, development and follow-up purposes, the project has been split into six distinct modules, with specific responsibilities and objectives. The following article presents a summary report of the responsibilities and results for each of the modules.

Contexte

Le Service hydrographique du Canada (SHC) de la région Laurentienne effectue annuellement sur le fleuve Saint-Laurent des relevés bathymétriques servant à contrôler la profondeur nominale du chenal de navigation d'une longueur de 300 km. Pour effectuer ces sondages, l'approche actuelle nécessite l'utilisation de planches à marée (échelle graduée placée le long des quais) ou de marémètres installés à des endroits spécifiques le plus près possible du secteur de travail. Dans les deux cas, les données sont transmises par radio jusqu'à l'hydrographe à bord du navire. Dans certaines zones, il est nécessaire d'utiliser simultanément plusieurs planches ou appareils; une interpolation des lectures est effectuée ensuite pour réduire le niveau de l'eau à la sonde bathymétrique. L'intégration hydrographique des données de niveaux d'eau sur le navire se fait par l'intermédiaire d'une application appelée AutoMarée. Pour la région comprise entre Montréal et le Cap Gribane (limite aval de la Traverse Nord), le SHC doit utiliser de 60 à 70 planches à marée, ce qui ne répond plus au contexte économique actuel.

À l'été 1996, le déploiement de l'infrastructure permanente du réseau DGPS de la Garde côtière canadienne (GCC), associé au contexte technologique actuel, a ouvert la porte à l'utilisation de l'approche On-the-fly ou OTF, une méthode de résolution de l'ambiguité de phase du GPS dans un mode de positionnement relatif cinématique. Appliquée aux sondages bathymétriques du chenal sur le Saint-Laurent, l'approche OTF pourrait permettre l'élimination des planches à marée qui servent à réduire les sondes bathymétriques au datum de référence des cartes marines ou zéro des cartes (ZC). Afin d'être en mesure de valider les résultats de l'approche OTF, un système d'intégrité basé sur un modèle unidimensionnel du fleuve Saint-Laurent a été également développé.

Le SHC, la GCC, l'entreprise privée et les institutions d'enseignement en géomatique travaillent conjointement

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depuis quelques années, à mettre en place la technologie DGPS-OTF pour les travaux de sondage hydrographique à bord des navires de sondage travaillant dans le chenal de navigation entre Montréal et l'île-aux-Coudres. Pour des besoins de planification, de développement et de suivi, le projet a été divisé en six modules distincts avec des responsabilités et des mandats spécifiques. Le présent article présente un compte rendu sommaire des responsabilités et des résultats associés à chacun des modules.

Module 1: Développement du logiciel OTF-RT (BathyKin)

Le système GPS est devenu, au cours des années, un excellent système de positionnement pour plusieurs applications qui ont besoin d'une référence spatiale soit horizontale ou verticale. Avec l'émergence de nouvelles techniques pour la détermination de l'altitude avec GPS, telle que l'OTF, il est maintenant possible d'utiliser la précision associée à cette technique pour la détermination de la hauteur du niveau de l'eau dans un mode de positionnement relatif cinématique. Rappelons que la solution OTF est obtenue à partir des observations de phase GPS et que la précision visée amène la modélisation rigoureuse des erreurs inhérentes au système GPS.

Pour les besoins du sondage bathymétrique, la précision recherchée pour la mesure de la hauteur du niveau d'eau est de ± 10 cm à 95% du temps. La solution OTF doit être obtenue à l'intérieur d'un délai maximum de trois minutes. Le développement des algorithmes OTF a été confié à la compagnie VIASAT et au Dr Rock Santerre du Centre de recherche en géomatique de l'Université Laval. En plus de la mise au point des algorithmes, VIASAT a eu le mandat de développer l'interface-usager adaptée aux besoins des levés hydrographiques et essentielle à l'utilisation de l'OTF. Ce logiciel se compose de deux modules distincts à savoir: le logiciel de contrôle de la station de référence et le logiciel de contrôle et de traitement du navire.

En 1994, des tests préliminaires avec OTF ont montré que la solution était applicable jusqu'à plus de 75 km, et dans les précisions fixées au départ. Selon ces premiers résultats, la solution OTF était utilisable immédiatement. Cependant, l'augmentation des effets ionosphériques au cours des années subséquentes, dûe à l'augmentation de l'activité solaire, a dégradé rapidement la performance de la solution réduisant la portée du système à moins de 40 km. Rappelons que cet effet atteindra un maximum au cours des deux ou trois prochaines années.

Tel que mentionné par St-Pierre, les observations de phase GPS sont biaisées par diverses sources d'erreur dont en particulier le délai ionosphérique. Des travaux de recherche sont actuellement en cours pour modéliser ce délai et permettre ainsi d'approcher la précision et les limites d'application recherchée. La modélisation rigoureuse des erreurs associées au signal GPS est d'une importance capitale étant donné la nécessité de résoudre les ambiguïtés de phase. Principalement, à cause de la réfraction ionosphérique, la méthode de résolution OTF est actuellement limitée à de petites lignes de base. Notons que la limite de 40 km est régulièrement franchie pour un navire de sondage sur le fleuve Saint-Laurent qui utilisera le réseau DGPS-OTF de la GCC dont la distance entre la station de référence et le navire peut atteindre 75 km. Le réseau actuel inclut trois stations OTF: Lauzon, Trois-Rivières et L'Acadie.

Module 2: Développement d'une table d'ondulation du zéro des cartes

L'utilisation du GPS et de l'OTF lors des levés hydrographique permet de déterminer la hauteur du niveau de l'eau à l'endroit exact du navire. Cette technique donne une élévation ellipsoïdale en référence à un datum comme le WGS84 alors que les besoins hydrographiques exigent que cette valeur soit référée au datum utilisé pour la cartographie marine soit le zéro des cartes (ZC). Le développement d'une table d'ondulation du ZC par rapport à l'ellipsoïde de révolution a donc été rendu nécessaire.

En hydrographie, les valeurs de la profondeur sont données par rapport à une surface de référence arbitraire appelée "zéro des cartes". Cette surface est dite "arbitraire" car la considération première est la sécurité de la navigation et n'est généralement pas définie par des concepts et équations mathématiques compliqués. Or, cette surface de référence n'est exactement connue qu'aux sites de référence (endroits équipés d'enregistreurs de niveaux d'eau). Lors des opérations de sondage en hydrographie traditionnelle, un des problèmes soulevés est la réduction du niveau d'eau entre les sites d'enregistrement de la marée. La solution actuelle, pour réduire la profondeur au ZC, consiste à effectuer une interpolation linéaire de la marée ou à utiliser des cartes cotidales indiquant les valeurs prédéterminées de réduction. On note que la problématique est accentuée aux endroits où la marée se propage de façon non-linéaire.

L'utilisation de la technologie OTF en temps réel pour les besoins de sondage requiert donc la détermination des différences entre la valeurs ellipsoïdales et le ZC en tout point pour un secteur donné de sondage. On appelle ce modèle, le modèle de séparation du ZC qui s'inspire du modèle d'ondulation du géoïde. La relation découle d'une utilisation d'une surface de référence connue et continue, d'où l'expression anglaise de "Seamless datum".

En collaboration avec la GCC et Levés géodésiques du Canada, le SHC a entrepris en 1995-96 un levé géodésique dans le but de déterminer l'altitude orthométrique des repères de nivellement qui servent à l'établissement du Zéro des cartes dans le tronçon Montmagny - Montréal. À partir de 108 points de contrôle

(33 repères de nivellement et 75 repères secondaires ou intermédiaires), dont les valeurs géodésiques en NAD83-CSRS et celles au ZC sont connues, une grille régulière de six secondes d'arc donnant, pour chacun des noeuds, la différence entre l'ellipsoïde et le ZC, a été développée. La technique d'interpolation par krigeage a été utilisée car elle respecte intégralement les valeurs des points de contrôle et nous permet d'obtenir également une précision estimée aux noeuds. La grille a été ensuite intégrée directement aux applications développées par la compagnie VIASAT.

Ainsi, à partir de la solution OTF qui nous donne la hauteur de l'antenne GPS par rapport à l'ellipsoïde (H), de l'écart entre le ZC et l'ellipsoïde déterminée à partir de la position du navire et de la grille (Nz), de la hauteur de l'antenne par rapport à la surface de l'eau (K), considérée stable pour une vitesse donnée, nous pouvons calculer le niveau d'eau (M) à la position du navire par la relation suivante:

$$M = Nz - H - K \qquad (1)$$

Module 3: Développement/déploiement du système de communication

Le mandat consiste à mettre en place les infrastructures de communication nécessaires pour la transmission des données GPS des trois stations de référence OTF de Lauzon, Trois-Rivières et L'Acadie/St-Bruno vers les navires de sondage. Dans le cadre de ce projet, l'équipement permettant la transmission simultanée des données de niveaux d'eau du réseau d'information SINECO et du GPS a été installé. Le type de communication principal consiste en un lien radio et vise à offrir une couverture de 70 km autour de chaque site. Le lien offre une vitesse de 9.6kbps utilisant le protocole FEC ("forward error correction") propriétaire de la compagnie Dataradio. La transmission des données est de type "broadcast mode" unidirectionnel terre vers navire et permet plusieurs usagers simultanément. Le lien radio offre trois canaux de données grâce à l'ajout d'un dé-multiplexeur sur le navire (données OTF sur port 1 et données SINECO sur port 2 actuellement).

Module 4: Intégration hydrographique sur le navire FCG Smith

Une panoplie de tests ont été effectués sur le navire hydrographique FCG Smith durant la saison de sondage 1998. Ces tests préliminaires avaient pour but de vérifier "l'opérationnalité" de l'équipement et des applications et d'évaluer le potentiel de la technologie OTF pour le sondage. Les essais ont permis également de vérifier la stratégie d'implantation de l'OTF avec les hydrographes à bord du navire. Des modifications ont également été effectuées au logiciel d'intégration des données bathymétriques HYDAS.

Module 5: Développement du système d'intégrité des niveaux d'eau mobiles (SINEM)

Dans le monde maritime, il est acquis que l'utilisation d'un système indépendant vienne confirmer l'information obtenue d'un système principal de navigation. C'est notamment le cas du radar qui confirme l'information de la carte électronique et du DGPS. La technique utilisée pour valider la solution OTF est basée sur l'utilisation des niveaux d'eau obtenus en temps réel du réseau de marémètres SINECO déployé sur le fleuve Saint-Laurent et des résultats du modèle hydrodynamique unidimensionnel OneD-STLT de la GCC. Une application conjointe effectue une interpolation en temps réel, dans le temps et l'espace, des niveaux d'eau provenant des deux sources précédemment citées. Un logiciel de contrôle de l'intégrité indépendant fait la comparaison de la solution OTF au niveau interpolé, prépare le sommaire des statistiques et déclenche une alarme en cas d'écart prononcé des deux solutions.

De façon succincte, la première étape des calculs de l'interpolateur consiste à calculer le niveau d'eau "prévu" au navire à l'aide d'un modèle de prévision des niveaux d'eau du fleuve Saint-Laurent. Les intrants consistent aux prévisions de débits du fleuve et de ses tributaires, et des prédictions de niveaux d'eau aux limites du modèle. Par la suite, le niveau "prévu" est ajusté en fonction des niveaux mesurés en temps réel aux stations SINECO à proximité du secteur de sondage. Le modèle et les mesures aux stations SINECO fournissent des niveaux d'eau ponctuels dans le temps et l'espace, alors que les activités de sondage et le déplacement du navire nécessitent un niveau d'eau mobile, i.e. quasi-continu le long de son déplacement sur le chenal. Pour cette raison, l'interpolateur, comme son nom l'indique, interpole les différents niveaux dans le temps et l'espace pour déterminer le niveau d'eau au temps précis du sondage.

Les calculs de l'interpolateur peuvent être lancés en temps réel ou en post-traitement pour une journée particulière. L'interpolation en temps réel se fait via une application graphique sous Windows appelée SINEM, qui s'occupe de recueillir les données de déplacement et les niveaux d'eau mesurés aux stations SINECO au fur et à mesure que se déplace le navire.

Module 6: Banc d'essais

Au cours de l'automne 1999, une série de tests ont eu lieu sur des sites choisis sur le fleuve Saint-Laurent. Les objectifs spécifiques du banc d'essai étaient de:

- Démontrer les capacités de l'OTF à déterminer une hauteur de niveau d'eau à bord d'un navire de sondage;

- Comparer les hauteurs d'eau offertes par BathyKin (logiciel OTF) et SINEM (modèle STLT) par rapport aux hauteurs fournies par les planches à marée (AutoMarée);

- Valider la précision, la stabilité et la répétitivité des solutions;

- Vérifier la couverture radio à proximité des stations de référence de Trois-Rivières et de Lauzon;

- Valider la table d'ondulation pour la réduction au Seamless Datum;

- Vérifier les sources potentielles d'erreurs, connaître la nature de celles-ci et comprendre les différences;

- Tester l'équipement OTF de la compagnie SERCEL afin d'être en mesure de comparer avec BathyKin de VIASAT;

- Établir les recommandations pour la poursuite du projet.

Les essais ont été effectués en modes statique et dynamique jusqu'à une distance de 30 km des stations de référence OTF de Trois-Rivières et de Lauzon et selon la disponibilité de la solution OTF. Les secteurs de Trois-Rivières et Lauzon représentent successivement une zone sans marée et une zone à marée. Les stations du réseau SINECO, à proximité des deux secteurs à l'étude, ont été également mises à contribution. Les hauteurs d'eau obtenues par OTF et SINEM seront comparées aux hauteurs d'eau obtenues des planches à marée (et par AutoMarée). Une station OTF portative a été utilisée pour la validation des solutions OTF en temps réel mais également pour la validation de la table d'ondulation pour la réduction au Seamless Datum.

Conclusion

Les résultats préliminaires du banc d'essai de l'automne 1999 montrent déjà la possibilité d'éliminer des planches à marée dans certains secteurs de sondage. Des améliorations et des corrections devront être faites aux applications et au système de communication. L'intégration d'un modèle ionosphérique est essentielle pour atteindre les limites d'opération et les précisions visées dès le début du projet. Des efforts de validation des solutions sur d'autres secteurs de sondage du fleuve sont à prévoir.

Les deux alternatives proposées au remplacement des planches à marée, l'OTF et le modèle hydrodynamique, présentent un potentiel fort intéressant. La solution OTF est très avantageuse pour le sondage car elle permet l'optimisation des techniques de sondage et de dragage. Dans le contexte actuel d'intégration sur le navire, elle permet une appréciation des niveaux d'eau à l'endroit même du navire et n'est pas une interpolation. L'autre solution est essentielle dans la mise en oeuvre de l'OTF sur le fleuve Saint-Laurent; elle fournit un niveau d'eau interpolé à l'endroit même du navire et permet ainsi une comparaison entre les diverses solutions proposées et les planches à marée.

Il va de soi que l'utilisation combinée des approches OTF et du modèle hydrodynamique diminueront sensiblement les coûts opérationnels des levés bathymétriques sur le fleuve Saint-Laurent. Cependant, nous sommes loin de restreindre les bénéfices que permettra une telle technologie à une application unique au sondage. Déjà, des bénéfices directs pourraient découler de l'utilisation de cette technologie dans le monde de la navigation commerciale pour les navires à fort tirant d'eau (évaluation du squat) ou à son utilisation pour des cartes numériques dynamiques.

Référence:

St-Pierre, Claude; 1999, *Modélisation du délai ionosphérique relatif en vue de la détermination des ambiguïtés de phase GPS*; Mémoire de maîtrise présenté à la Faculté de Foresterie et de Géomatique, Département des Sciences géomatiques, Université Laval, Avril 1999, 126 pages. ●

Carbon - The Heart of Climate Change[3]

by Trevor Murdock[4] and Rick Lee[4]

Carbon forms the basis of all life on the planet. It is found in the oceans, in living biomass and in the lithosphere (e.g. coal). Just how carbon moves to and from these three main storage areas - is the key to understanding what we call the "Carbon Cycle". Although our present knowledge of this cycle is incomplete, it can help our understanding of some important questions:

- How severe will impacts of climate change be?
- How much do we need to reduce carbon emissions in order to reduce impacts of climate change?
- If the climate system is perturbed [given a push], will the current climate reestablish itself or perhaps shift to a different climatic equilibrium? If so, after how long?
- Other than reducing fossil fuel emissions, are there other ways of reducing carbon dioxide levels in the atmosphere?
- How does the current situation compare to the past climate record?

Sources and Sinks

The basic components of the carbon cycle are depicted in the accompanying figure and comprise: -"sinks" - processes through which carbon dioxide is removed as a gas from the atmoshpere and stored, and "sources" - processes in which carbon dioxide gas is released into the atmosphere from one of the sinks.

The major sinks in approximate order of largest to smalllest are marine sediment and rock, ocean, fossil fuel deposits, soil, forests (and all plants) and lastly - the atmosphere, the smallest but most significant sink. The size of some of these major sinks of carbon is currently the subject of much debate as the uncertainties in estimating their quantities are still fairly large.

Of course, the earth-atmosphere-ocean system contains a fixed amount in each part of the system at any time that is crucial. Our primary concern is the amount that remains in the atmosphere as carbon dioxide.

Transferring Carbon between Sinks

The mechanism for carbon dioxide "uptake" by the ocean is diffusion - the atmospheric carbon dioxide essentially dissolves into the ocean. While some carbon is stored in the ocean itself, it is also precipitated out of the ocean (sinks to the bottom) as calcium carbonate deposits which eventually turn into sediment and rock. This in turn allows more carbon to diffuse into the ocean. Naturally, this is oversimplification of a more complicated process that is also influenced by several other factors such as the temperature of the water surface, the rate and depth of ocean mixing and surface plankton.

Carbon dioxide uptake by forests and other plants takes place through photosynthesis which locks carbon into living biomass as well as into the soil. Locking carbon dioxide into biomass is actually temporary, as eventually it becomes a source to the atmosphere through decomposition of organic matter. Removal of biomass, for example, through cutting of forests, in itself does not result in an immadiate decrease of biomass. Wood is used in structures and carbon remains stored. Only the by-products of forestry left to decompose become immediate sources of carbon for the atmosphere. As long as the amount of carbon that is released to the atmosphere equals that which is sequestered by living biomass, the total carbon capacity remains constant. When forests are removed, the capacity diminishes. When the land is reforested the capacity increases.

Respiration in the diagram overleaf represents the symbiotic relationship of animals to plants where animals breathe in the oxygen produced by photosynthesis and breathe out carbon dioxide, which plants then use in photosynthesis and produce oxygen again. This is a relatively small portion of the carbon cycle so that changes in this type of carbon dioxide do not affect the overall picture significantly. Finally, since the beginning of the industrial revolution, humans have added a new source of carbon dioxide to the atmosphere - through the burning of fossil fuels. The result has been an increase in atmospheric carbon dioxide levels by about 30%. In the context of global warming, this is essentially an irreversible process because, once depleted, fossil fuels cannot be re-synthesized and stored as they once were.

Debates

Burning of fossil fuels is not the only human activity or "anthropogenic" source of carbon dioxide. Changes in land-use also have been a major contributor. Cutting of forests

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[3] First published in "The Climate Network", Vol.4, No.4, Winter 1999, p. 5-7. Reproduced here with the authorization of the authors.

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and tilling of land have resulted in a net increase of carbon in the atmosphere since the 1700s. In recent decades, growth of new forest has, in fact, provided increased storage - temporary sink - for carbon. Recent findings published in the New Scientist, however, suggest that relying on new forest for carbon uptake may be dangerous as estimates of the capability of forests to act as sinks are grossly overestimated simply because plants do not respond beyond a certain level of atmospheric carbon dioxide and some scientists believe that point is near. In the long term, forests can only retain carbon if the land is left to forestry in perpetuity. Even then, suggestions are now being made that as the global temperature rises, plant matter will decay and release carbon dioxide into the air, ultimately making forests a net contributor of carbon dioxide. The wisdom of using forests as a permanent sink is thus coming into question.

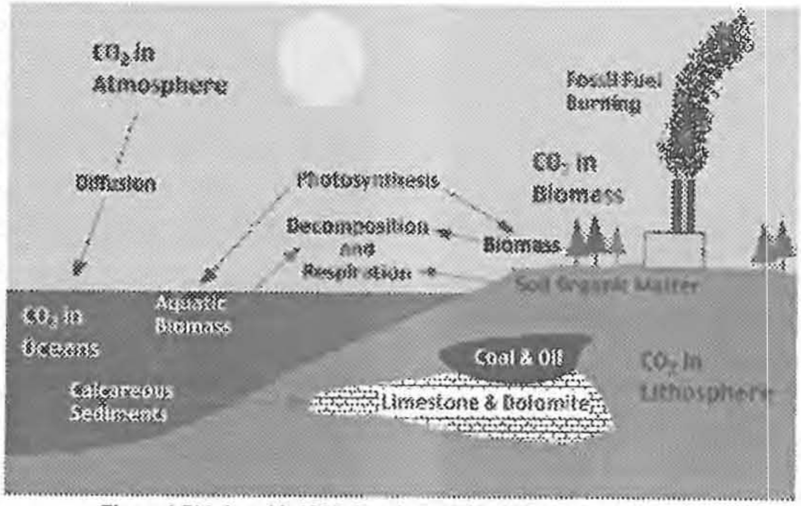

Figure1 Pidwimy, M. 1999, Fundamentals of Physical Geography http://www.geog.ouc.bc.ca/physgeog

The debate over the capacity of carbon sinks is not restricted to forests. Carbon sequestration - the artificial and natural trapping of carbon dioxide in a sink to remove it from the atmosphere - is an intense area of ongoing research that has recently received some major boosts in funding in the US. Potentially promising areas of carbon sequestration research include:

- conversion of agricultural practices to non-tilling or conservation tillage;
- binding of carbon dioxide to minerals;
- pumping liquid carbon dioxide deep into the ocean; and,
- artificial stimulation of oceanic uptake of carbon.

None of these methods of storing carbon however would be as effective as keeping carbon stored in its fossil form. This means civilization needs to convert to sustainable energy sources such as solar radiation and wind. There are many hurdles to overcome to achieve effective carbon sequestration - including ensuring potential carbon sinks are not temporary or damaging to the environment.

Some of the most daunting unanswered carbon cycle questions surround potential "positive feedback" mechanisms. An example of a positive feedback mechanism is found in Arctic permafrost. Initial global warming melts snow and ice, changing the surface albedo [reflective qualities of the earth's surface]. Land areas no longer covered in white snow or ice absorb more of the sun's radiation, the land warms and the permafrost melts, methane and carbon dioxide are released from peat which enhances the greenhouse effect and leads to more global warming. Melted permafrost is believed to be a potentially major source of greenhouse gases. Recent warming in the Arctic regions has focused research on this feedback mechanism and much remains to be learned.

The Carbon Cycle in the Past

What is known about fluctuations in atmospheric carbon dioxide levels in the past? How do the current levels compare to historical peaks? Research findings in this area recently received a major boost with the completion of the analysis of the Vostok ice core record. This Antarctic record shows the fluctuations in atmospheric carbon dioxide levels (as well as methane) over the last 420,000 years. Four peaks in carbon dioxide levels have been identified during this record, all of which were smaller in magnitude than the current carbon dioxide concentration in the atmosphere. When this record of atmospheric carbon dioxide is placed in juxtaposition to Earth's temperature, a picture emerges.

It appears that the carbon dioxide level changes in the past were accompanied by similar rises and falls in temperature. There is also some linkage to solar radiation fluctuations, but that relationship is not nearly as strong as between carbon dioxide and air temperature.

According to the scientists analysing the Vostok cores, not only are carbon dioxide levels currently higher than at any point in the last 420,000 years, but also these levels continue to increase at a rate greater than observed in the past. It is disturbing to note that after each peak the global temperatures dropped two degrees, sometimes rapidly, sometimes gradually. Temperatures then fell slowly over several millennium into glacial conditions. We are left to wonder if human activity could accelerate the arrival of the peak atmospheric loading of carbon dioxide and thus usher in the next cycle of glaciation prematurely?

Clearly there are important issues to be addressed, not only in the manner in which we produce energy but also in understanding the carbon cycle, anthropogenic influence on the cycle, carbon sequestration and potential for positive feedback mechanisms. There continues to be a need for further research that will lead to a deeper understanding of climate and to improvements of models of climate change. •

Long Term Flux Measurements at the Borden Forest

by

R.M. Staebler[1], J.D. Fuentes[2], X. Lee[3], K.J. Puckett[1], H.H. Neumann[1], M.J. Deary[1], J.A. Arnold[1]

Résumé

Ce manuscrit donne une vue d'ensemble des activités de recherche qui ont été menées au site de recherche de Environnement Canada à Borden, située près de Angus, Ontario. Ce site forestier fut une des premières installations de recherche établies en Amérique du nord pour étudier les échanges à long terme d'énergie, momentum, gaz à faible concentration et particules de matière entre la surface et l'atmosphère. L'accent initial fut mis sur le développement d'une compréhension théorique du transport turbulent sous un couvert végétal, et sur l'étude du rôle des écosystèmes forestiers dans la réduction des espèces chimiques réactives et des particules de matière. Plus récemment, l'accent de la recherche a été l'étude de l'efficacité des écosystèmes forestiers à séquestrer le dioxyde de carbone et à produire des hydrocarbones biogéniques. On sait que ces derniers composés sont des précurseurs efficaces d'oxydants dans des environnements riches en oxydes d'azote. Sur la foi de cinq ans de mesures continues de dioxyde de carbone au dessus des cimes, la forêt de Borden est un puits efficace de dioxyde de carbone. Comme on s'y attend, l'extraction de dioxyde de carbone est fortement modulée par le climat. Par exemple, l'absorption nette de carbone par la forêt Borden durant 1995, 1996, et 1997 se chiffraient respectivement à 1.0, 1.2 et 2.8 tonnes de carbone par hectare. Les différences inter-annuelles dans la séquestration de carbone dépendaient des conditions environnementales existantes; la quantité élevée de carbone capturé en 1997 était causée par une plus basse température du sol durant la saison de croissance, qui favorisait une moins grande respiration du sol.

1. Introduction

The Environment Canada research facility at the Canadian Forces Base (CFB) Borden was established in 1985 to conduct investigations in the general area of biosphere-atmosphere interactions [den Hartog and Neumann 1984]. The first Canadian investigations on dry deposition of gaseous pollutants (such as ozone, nitrogen dioxide and sulfur dioxide) to forests were carried out at Borden during 1985 and 1986. This research involved pioneering applications of the eddy covariance technique to characterize pollutant deposition rates during fall and winter conditions [Edwards et al. 1988; Padro and Edwards 1991; Padro et al. 1992]. In 1986, an unprecedented study took place in which seven three-dimensional sonic anemometers were deployed on a 45-m tower to investigate characteristics of atmospheric turbulence above and inside the Borden forest [den Hartog et al. 1987; Shaw et al. 1988; Leclerc et al. 1990; Maitani and Shaw 1990; Shaw et al. 1990; Shaw and Zhang 1992]. In 1987, a comprehensive tree survey, combined with leaf area index (LAI) measurements using leaf litter collection and hemispherical photography, provided detailed information on the amount and distribution of foliage in the forest canopy [Neumann et al. 1989]. From 1988 to 1990 major field campaigns were carried out in support of the Canadian acid deposition research program. In particular, a major component of the Eulerian Model Evaluation Field Study took place at Borden during 1988. These investigations [Padro et al. 1991; Fuentes et al. 1992; Barr et al. 1994] provided not only the observational data bases to develop and test photochemical models to estimate regional pollutant deposition to terrestrial environments, but also a fundamental understanding of the atmospheric and biological controls on vegetation pollutant uptake. Because the vegetation at Borden remains wet for a substantial period (~50%) of the growing season, specific studies [Fuentes et al. 1994a, b] were carried out to discern the role of foliage wetness on pollutant deposition. In the context of long-term flux measurements, we must mention the first Canadian year-round measurement of forest carbon dioxide (CO_2) fluxes using micrometeorological methods attempted by Ken King in 1987 [Perttu 1990].

Since its establishment, Borden has been the staging facility to test sophisticated atmospheric measurement systems. In 1993, the flux measuring systems employed in the BOREAS (BOReal Ecosystem-Atmosphere Study) project by several Canadian research teams were fully tested and inter-compared at Borden. One specific focus of these studies was to unveil the reasons for high uncertainties associated with nocturnal trace gas fluxes [Lee et al. 1996; Lee 1996]. Also, since Borden is situated in the southern region of Canada impacted the most by anthropogenic activity [Fuentes and Dann 1994], intensive field measurement campaigns were initiated in 1993 to ascertain the biogenic hydrocarbon source strength from deciduous forests [Fuentes et al. 1996; Fuentes and Wang 1999; Fuentes et al. 1999]. These field studies were required to assess the influence of biogenic chemical species in local and regional oxidant formation. Recognizing the importance of these biogenic

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hydrocarbons in oxidant formation in southern Ontario, Environment Canada scientists pioneered investigations to understand the seasonal and environmental controls on hydrocarbon emissions from forested ecosystems in 1995 [Fuentes et al. 1996]. At the same time, intensive field campaigns were undertaken to learn the degree of photochemical processing within forest canopies [Makar et al. 1999]. To develop and test photochemical models, it was necessary to understand the disposition of total global radiation and actinic irradiance inside the Borden forest canopy [Staebler et al. 1997]. A trolley system carrying radiometers was used near the forest floor to establish averaged quantities as the trolley traversed a 30-m distance. These studies were augmented with shorter field campaigns to test theoretical developments on the calculation of trace gas fluxes from or to forests using gradient methods [Simpson et al. 1998]. The data sets obtained at Borden have been critical to develop and test biospheric and photochemical modeling systems [Fuentes et al. 1999; Huber et al. 2000; Makar et al. 1999].

Recognizing that most temperate forests in Canada were undergoing rapid growth, we initiated a continuous, long-term measurement program in 1995 with the goal to understand the sequestration capability of the Borden forest and how climatic perturbations such as drought can impact forest carbon uptake. To address the inter-annual and inter-seasonal variability of carbon uptake, we have been taking a plethora of ancillary measurements including the fluxes of water vapor, sensible heat, and momentum. Additionally, to explain the physical and edaphic variables controlling the forest-atmosphere gas and energy exchange, microclimate measurements have been made inside and immediately above the forest canopy. Thus, in this article, we report sample data sets to illustrate the magnitude of forest carbon dioxide sequestration and associated controls on the fluxes. Other articles [Lee et al. 1999; Fuentes et al. 1999; Hollinger et al. 2000] provide full description of data analysis results concerning the carbon sequestration capability of the Borden forest and hydrocarbon emissions.

2. Site description, climatology and measurements

The Borden forest is located in southern Ontario, Canada (44°19' N, 80°56' W; Figure 1 shown on back cover page). The research infrastructure at the site comprises a 45-m instrumented scaffolding tower and associated trailers to house gas analyzers, data logger, and computing equipment. The forest around the tower extends about 4 km from the south-southeast to the west-northwest sector, and about 2 km to the east. The forest is about 95 years old, representing natural re-growth on farmland that was taken out of cultivation in the early 1900s. Based on a survey conducted in 1995, the forest consists of 36% red maple, 21% trembling aspen, 14% white ash, 12% large tooth aspen, 5% white pine, 4% black cherry, and 8% other species. In 1995 the average canopy height was 22 m. Mid-growing season LAI averaged 4.2 (Figure 2A). The seasonal LAI measurements in this figure were obtained using a plant canopy analyzer and verified with area measurements of autumnal leaf litter fall [Staebler et al. 1997]. Defined from leaf emergence to complete leaf fall, the average growing season is from 20 April (day of year 111) to 20 October (DOY 294). Based on three years of data and in terms of carbon uptake by the forest, the growing season can range from the second week of May (DOY 125) to the second week of October (DOY 280).

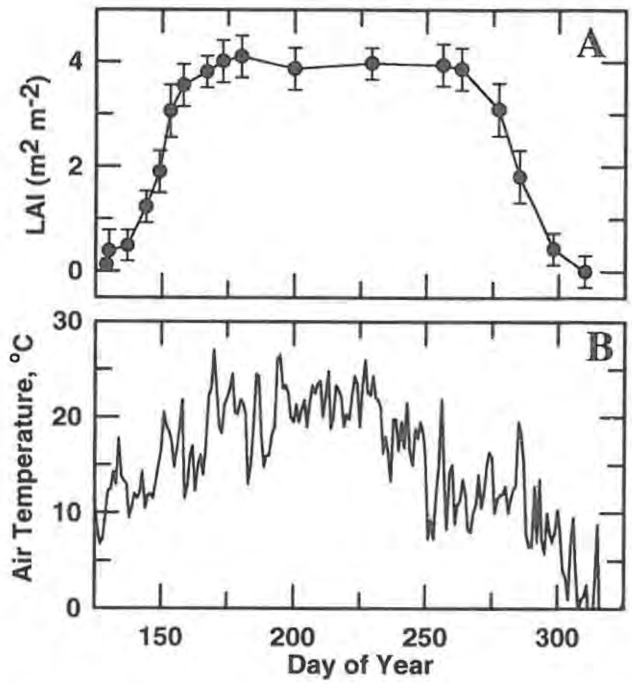

Figure 2. Leaf area index and daily average temperature for the 1995 growing season.

Based on 30-year climate averages, the Borden forest site receives 858 mm of precipitation annually with August and September being the rainiest months when total monthly precipitation can reach 100 mm. The average annual air temperature is 6.4°C and the daytime average vapor pressure deficit is 0.38 kPa. As shown in the air temperature signal for 1995 (Figure 2B), June, July and August are the warmest months when daily mean temperature can reach 20°C. In terms of availability of energy (net radiation), Borden experiences a total of 2.36 GJ per m^2 on average.

Current, continuous microclimate measurements are made inside and immediately above the forest canopy as shown in Figure 3. Measurements of air temperature (using ventilated copper-constantan thermocouples) at 12 levels above ground, wind speed and direction (R.M. Young anemometer model 0571, Traverse City, MI) at 45 m, incoming solar radiation (Model PSP pyranometer, Eppley Laboratory, Newport, RI), photosynthetically active radiation (PAR, Model LI190SA, LiCor Inc.) above the forest, and relative humidity (Model MP-100, Rotronic Instrument Corp., Huntington, NY) at 33 and 44 m above ground are continuously taken every minute. These data are subsequently reduced to derive half-hourly averaged quantities. Mixing ratios of CO_2 and water vapor (H_2O; Model LI-6262, LiCor Inc.) are determined at 6 heights. Both microclimate and gas mixing ratio measurements are acquired using data loggers (model CS21XL, Campbell Scientific Inc., Logan, UT). Gas profile measurements are made with a single gas analyzer, utilizing a manifold system and sequentially sampling air from individual intakes. At two sites soil temperature and moisture are measured at 6 depths. Additionally, bole temperatures are measured at four levels by inserting temperature probes in selected trees.

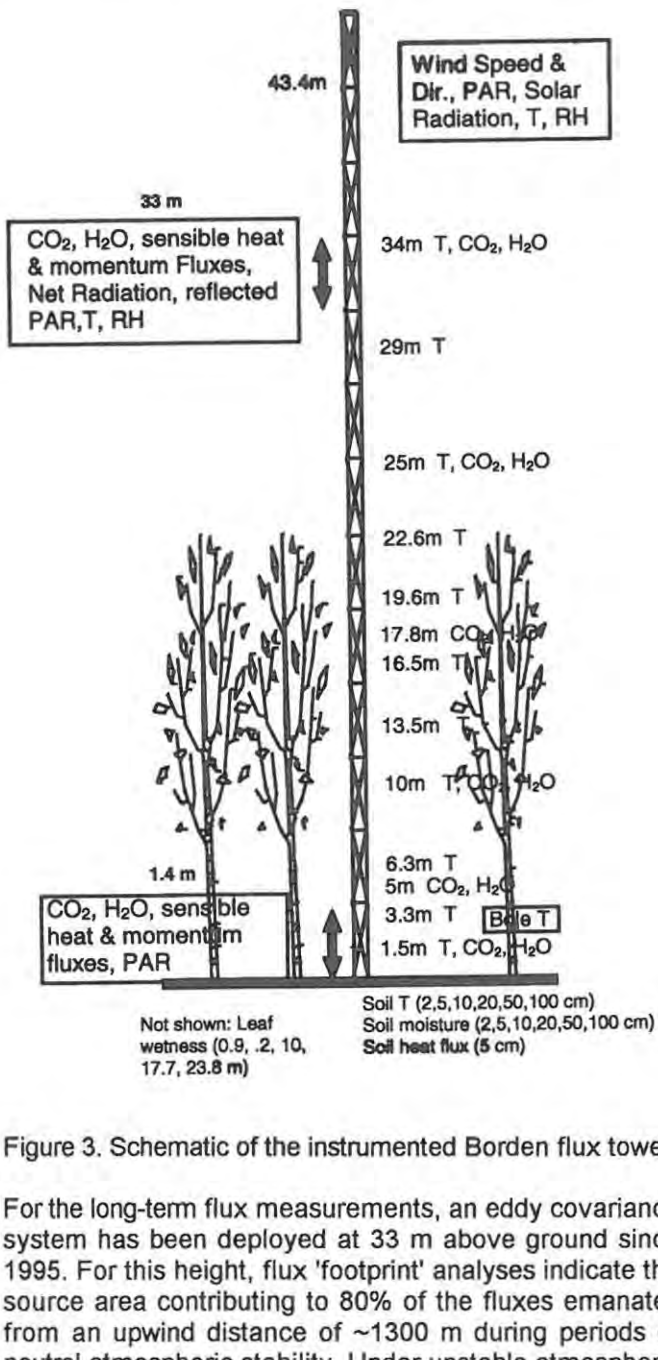

Figure 3. Schematic of the instrumented Borden flux tower.

For the long-term flux measurements, an eddy covariance system has been deployed at 33 m above ground since 1995. For this height, flux 'footprint' analyses indicate the source area contributing to 80% of the fluxes emanates from an upwind distance of ~1300 m during periods of neutral atmospheric stability. Under unstable atmospheric conditions footprints contract to less than 150 m. Eddy covariance fluxes are determined at 33 m above the ground using triaxial sonic anemometers (Model DAT-310, Kaijo Denki Ltd., Tokyo, Japan) in combination with fast-response gas analyzers. The fast-response measurements of CO_2 and H_2O vapor for eddy covariance are made with an infrared gas analyzer (model LI-6262, LiCor Inc.), operated in differential mode. Based on the flow rate of 6 L per min and the nominal sample cell volume of 11.9 cm^3, the gas analyzer time constant is 0.12 s. A second eddy covariance system was installed in the summer of 1999 to collect data on understory fluxes at 1.4m above the forest floor.

For both eddy covariance systems, a pumping system is used to bring the sampled air from the sonic anemometer level to the gas analyzers inside a hut at the base of the tower through tubing (Dekoron, aluminum tube with polyvinyl chloride coating and polypropylene lining). Air flow in the sampling tubes is maintained turbulent at all times as verified from calculations of Reynolds number. The fast response data provided by the sonic anemometers and gas analyzers are collected via a data acquisition and electronic signal conditioning system (model AT-MIO-16X, National Instruments, Austin, TX) that is interfaced with a computer which makes the computations of resulting eddy fluxes. The system records sensor outputs at 10 Hz and thus resolves frequencies of up to 5 Hz. Spectral analyses of the data collected at 33 m has revealed no appreciable fluxes beyond the frequency of 2 Hz.

In order to understand the atmospheric controls on the carbon dioxide fluxes, several eddy covariance measurements are also obtained. The momentum flux (τ) is determined from the covariances of longitudinal wind speed (u') and vertical wind speed (w') fluctuations, as shown in [1]. The air density (ρ) in [1] represents the average value obtained for the 30-min measurement period.

$$\tau = -\rho\, \overline{u' w'} \qquad [1]$$

From the τ data the friction velocity (u*) is calculated as shown in [2]. In our flux data interpretation, the u* is used to verify the turbulence regime above the forest. At Borden reliable eddy covariance fluxes are obtained when u* > 0.1 m s^{-1} [Lee et al. 1999].

$$u^* = \sqrt{\tau / \rho} \qquad [2]$$

Furthermore, the virtual heat flux (H_v) is necessary to discern the atmospheric stability conditions, and to learn how such factors can impact trace gas fluxes. As shown in [3], we derive H_v from the covariance of and virtual temperature fluctuations (T'_v) from the mean value. The sonic anemometer provides T_v. The ρC_p in [3] represents the air volumetric heat capacity.

$$H_v = \rho\, C_p \overline{W' T_v'} \qquad [3]$$

Net fluxes of H_2O and CO_2 (F_n) are determined as shown in [4]. The term ρ'_x represents the fluctuating quantity of H_2O vapor or CO_2 density, and F_c denotes the flux correction due to heat and humidity fluctuations in air density.

$$F_n = w'\rho_x + F_c \qquad [4]$$

By convention a negative value of $w'\rho'$ implies a downward flux whereas a positive quantity denotes the opposite. Thus, negative CO_2 fluxes denote forest CO_2 uptake whereas positive quantities imply CO_2 emissions (from soil and plant respiration). Over tall forests the CO_2 flux determined with the eddy covariance system does not necessarily yield net exchange during the period of integration. Errors can occur when CO_2 is stored in the air layer below the eddy covariance system. Thus, for the Borden forest we approximate the storage term by determining the temporal change in CO_2 ($\Delta\rho_{CO2}/\Delta t$) measured over a 30-min period at the height (z_r) of the eddy flux system. From this we estimate the net ecosystem exchange (NEE) of CO_2, or F_{eco}, as shown in [5].

$$F_{eco} = F_n - \Delta\rho_{CO2}/\Delta t\ Zr \qquad [5]$$

3. Forest-atmosphere carbon exchange

In this section we report sample data sets to illustrate the magnitude of CO_2 fluxes at scales ranging from hours to years. We also discuss the principal atmospheric controls on the variability of the fluxes.

The daytime eddy covariance fluxes represent the integration of two opposing CO_2 fluxes: one released from the soil and the other taken up by the forest. During the nighttime the CO_2 fluxes result from respiratory processes in soil and vegetation. Thus, because vegetation CO_2 uptake is energy driven, it is expected to have strong diurnal flux variability. Figure 4 shows a typical daily course of both H_2O (latent heat = LE) and CO_2 fluxes with strong diurnal variations for a day dominated by clear skies (see PAR in the top figure) and relatively warm conditions (maximum air temperature reaching ~25°C). For this day there was no evidence of soil moisture deficit, and both LE and CO_2 fluxes reached noontime peak values of 400 W m^{-2} and -1.0 mg (CO_2) m^{-2} s^{-1}, respectively.

A lag of almost 2 hours between the rise of PAR (starting at 6:30 h) and commencement of CO_2 uptake is apparent. Reasons for this include different threshold PAR levels for photosynthesis for the different tree species, penetration of sufficient amounts of light deeper into the canopy as the solar elevation angle increases, and the weak atmospheric turbulence during the night and early morning, which is enhanced significantly once the nocturnal stable layer has been eroded. The diurnal fluxes shown in Figure 4 are typical of those determined at Borden during mid-June to end of August, the time of the foliage senesce onset.

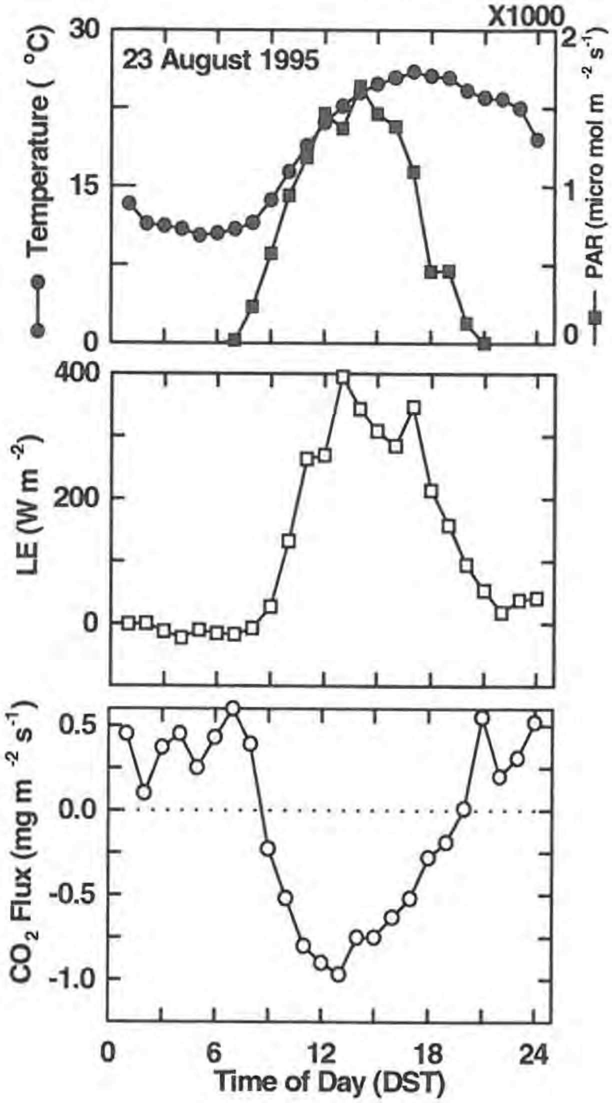

Figure 4. Diurnal variations of air temperature (•), Photosynthetically active radiation (PAR) (■), latent heat flux (□), and carbon dioxide flux (○) measured above the Borden forest during 23 August 1995.

Modulations on the fluxes occur if the forest experiences drought or other climatic perturbations.

To establish the seasonal patterns in CO_2 fluxes, integrated daily NEE quantities are calculated. These calculations have been made since 1995 to present, and Figure 5 shows a sample data set for the period from July 1995 to December 1997. Several features are important to note concerning Figure 5. First, the forest was a source carbon from October (day of year 275) to the end of May (DOY 145). For this period, average daily and maximum NEE values reached 2 and 5 mgC m^{-2} d^{-1}, respectively. Second, the growing season typically lasted 120-130 days. During the middle of the growing season, the forest carbon consumption reached nearly -10 mgC m^{-2} d^{-1}, respectively.

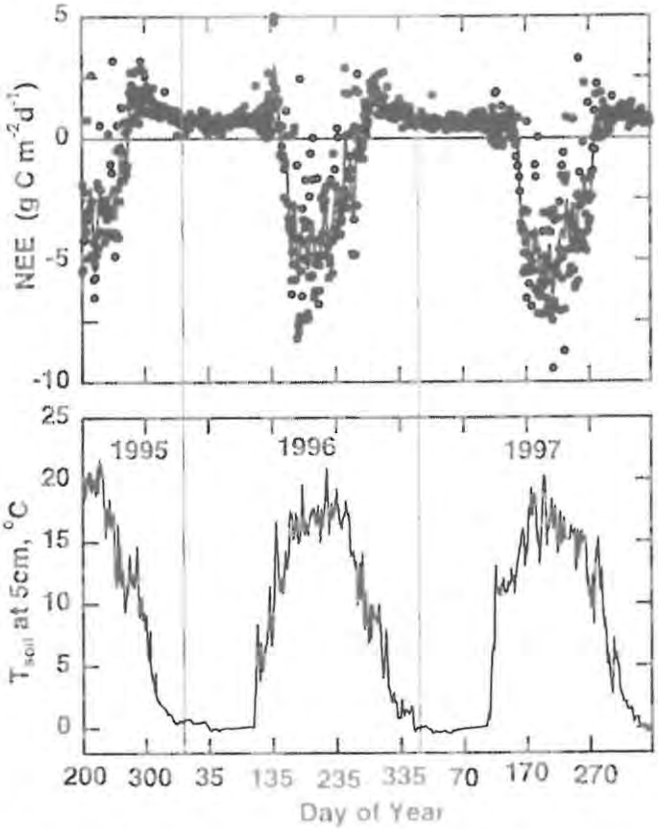

Figure 5. Daily NEE and daily mean 5-cm soil temperature for the Borden forest during the period of July 1995 to December 1997. For the upper figure the dots represent the measurements and the solid line corresponds to the average values.

The solid line represents the best to the data points. Integrating the daily NEE values over a year, the Borden forest sequestered carbon at the rate of 1.3, 1.4 and 2.8 tones ha^{-1} yr^{-1} during 1995, 1996 and 1997, respectively. Below we elucidate some of the environmental controls on the variability in the forest carbon sequestration.

The discrepancy between the annual integrated NEE during 1996 and 1997 (Figure 6) may be related to the differences in soil temperature. Soil temperature was 1°C and 0.25°C lower over the growing season and the full year, respectively, in 1997 than in 1996 (see Lee et al. [1999] for further details). Air temperature averages for both years were nearly the same. Thus, the effect of lower soil temperature in 1996 was to reduce litter decomposition rates and hence decrease soil respiratory losses. Two drought periods (data not shown) during the growing season in 1996 also contributed to the lower NEE. One occurred around DOY 150 and the other around DOY 225. Data shows that during these two periods, the noontime forest-atmosphere CO_2 exchange was suppressed. Also, soil temperature exerts a strong influence on CO_2 fluxes. In Figure 7 we show an example of the relationship between nocturnal CO_2 fluxes and soil temperature at 5 cm during the 1997 growing season.

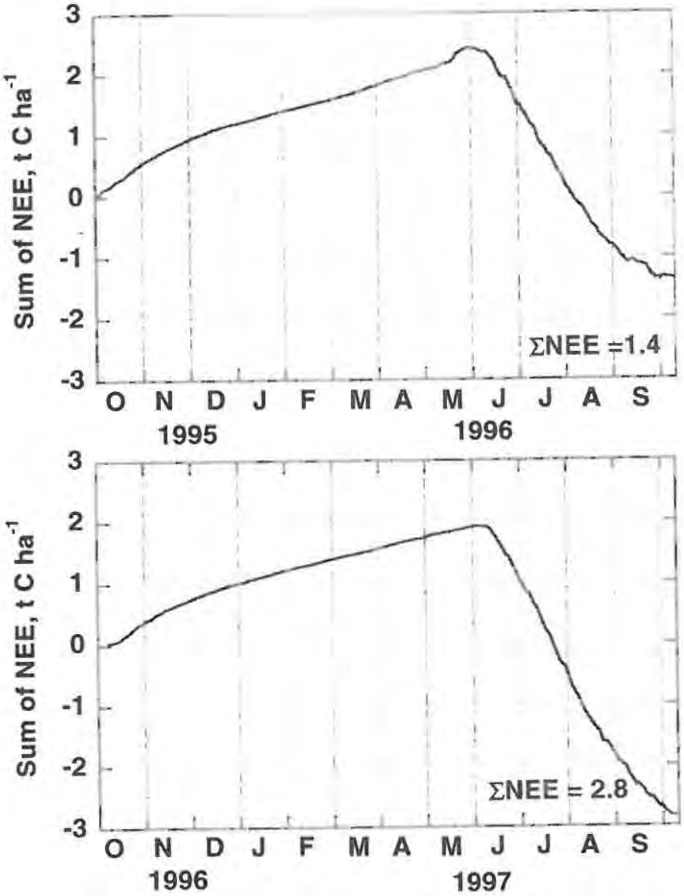

Figure 6. Yearly sums of net ecosystem exchange for carbon dioxide during 1995, 1996, and 1997.

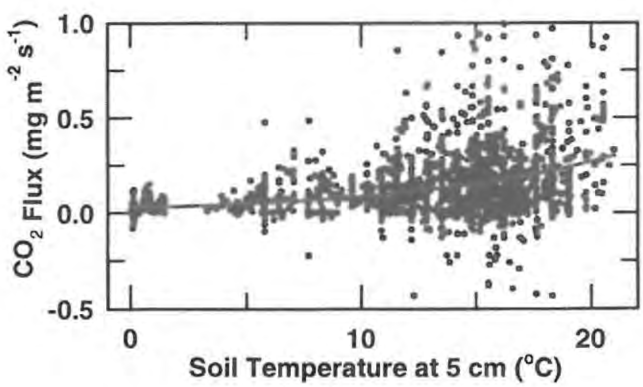

Figure 7. Nocturnal CO_2 fluxes during the growing season in 1997 as a function of soil temperature at 5 cm.

A multitude of physical and biological factors are influencing the capacity of the Borden forest to exchange carbon with the overlying atmosphere. One important biological factor is foliage ontogeny. Even though the forest retains its full LAI, drastic changes in NEE area observed towards the end of the growing season. For example, Figure 8 shows that even though the forest had a LAI of 4.2 (see Figure 2A) until DOY 270, systematic declines in NEE started around DOY 250. We believe that this early decrease in NEE capacity is related to leaf senescence, which reduces leaf photosynthetic capacity. Changes in leaf optical properties may also contribute due to smaller absorption of PAR, as revealed by the decrease in the light extinction coefficients (for PAR and global solar radiation) before the onset of falling of leaves (Figure 8). These measurements establish a link with remote sensing, and show how satellite data may be used to discern when these systematic declines in NEE occur in deciduous forested ecosystems.

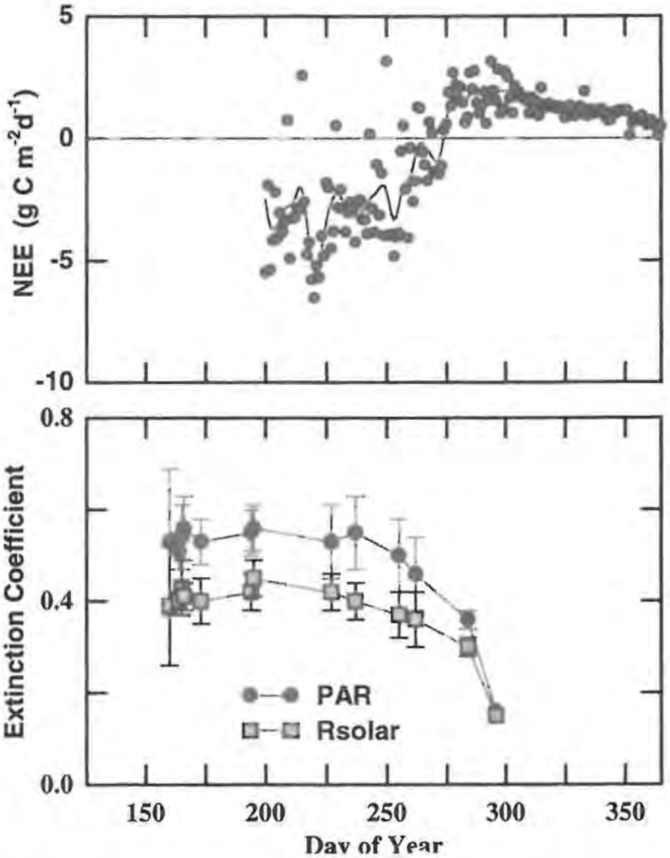

Figure 8. Daily NEE and canopy extinction coefficients for both PAR and short-wave (solar) radiation in the fall of 1995.

There is evidence that the atmosphere is becoming more cloudy and turbid, and thus enhanced diffuse radiation levels have been reaching the Earth's surface [Abakumova et al. 1996]. These climatic perturbations have direct implications in the manner in which forest ecosystems respond. Because diffuse radiation can more readily penetrate deeper depths in forest canopies, the radiation use efficiency can increase with increasing cloudiness up to a certain point, and thus CO_2 uptake can increase.

We have examined this effect for Borden [Gu et al. 2000]. In Figure 9, we report changes in NEE with the clearness index (the ratio of measured solar irradiance to clear-sky irradiance; for Borden under completely clear skies the index is ~0.8). For 1997 (Figure 9), the maximum enhancement of NEE ranges between 10 and 40% due to clouds. The changes in NEE varied with solar elevation angle (β).

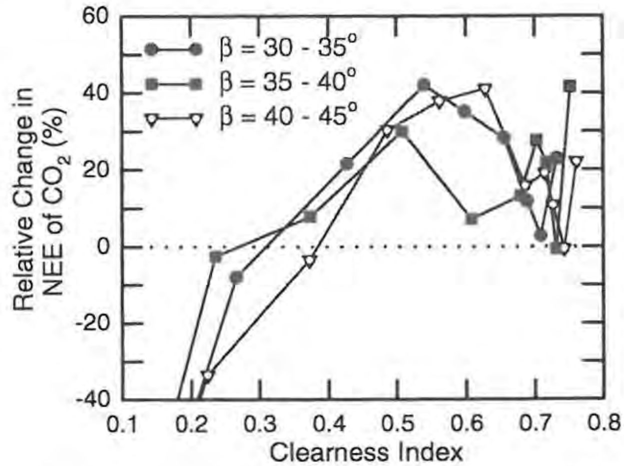

Figure 9. Relationship between relative changes in NEE of CO2 relative to clear skies and the clearness index for different intervals of solar elevation angles for Borden during 1997 (see Gu et al. 2000 for further details).

4. Summary and conclusions

Environment Canada established a research facility at CFB Borden in 1995 to undertake field studies of turbulence and fluxes of energy and mass within and above a deciduous forest in southern Ontario, Canada. Research programs conducted there in the subsequent decade have contributed significantly to our understanding of atmosphere-forest interactions. Since 1995, Environment Canada scientists have sustained an uninterrupted research program of flux measurements together with supporting microclimate observations at the Borden forest. This research program has identified and evaluated key environmental controlling factors on carbon exchange between temperate deciduous forests and the overlying atmosphere. Links between the inter-annual variability in exchange rates and the main controlling factors such as soil temperature, soil water availability, length of growing season, and light conditions have been studied. A growing data base on the interactions between the forest and the atmosphere at Borden has been established which can be used for further research.

Borden has also served international programs such as the Ameriflux network [Hollinger et al. 2000] because of its location at the northern edge of the temperate forest biome, and because of the unprecedented historical record of measurements dating back to the early days of micrometeorological experimentation in forests. Given that anthropogenic carbon dioxide emissions remain under international scrutiny as identified in the Kyoto Protocol [IGBP 1998], the information and knowledge being generated at the Borden forest will help in establishing a Canadian baseline for the magnitude of the biospheric carbon sink. Continued research at Borden can also assist Canada to meet its obligations under the Kyoto Protocol to improve our understanding of the role of forests in the carbon cycle, and how this role is affected by climate change.

Although the Borden research indicates that temperate deciduous forests in Canada sequester carbon at rates ranging from 1.5 to 3.5 tonnes of carbon per hectare per year [Lee et al. 1999, Hollinger et al. 2000], we do not know what portion of anthropogenically produced carbon is consumed by forests. Determining this will depend on obtaining a better understanding of the roles of respiration, soil exchange and advective factors in the carbon budget. Such information is critical to assess the progress being made in reducing atmospheric carbon dioxide levels. The Borden research group is currently developing research strategies to provide insights into quantifying the portions of biogenic versus anthropogenic carbon dioxide sequestered by forests.

Acknowledgements
Thanks are expressed to the Ontario Ministry of Natural Resources, who first suggested Borden as a suitable research site; to the Department of National Defence for allowing the work to proceed on their property; and to ARQB (Environment Canada) for supporting the project. We especially want to acknowledge the central role of Dr. Gerry den Hartog, our Site Captain, in establishing the site and running it for 10 years. We also want to thank Wes Kobelka, who looked after the installation of the facilities and the first tower.

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34th CMOS Congress / 34e Congrès de la SCMO
Victoria 2000

The role of the Pacific in Climate and Weather
L'influence de l'océan Pacifique sur le climat et le temps

29 may - 2 June 2000 UVIC 29 mai - 2 juin 2000

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A climate perspective on Toronto's blizzard of '99

Last January residents of the Greater Toronto area were inundated with a succession of storms that left a record amount of snow, 118.4 cm. This resulted from the placement of the jet stream such that the storm centres passed to the south of Toronto allowing for winds from the east and southeast to blow across Lake Ontario. This enabled the storms to pick up both energy and moisture. Typically, the Niagara Escarpment protects Toronto from receiving the amounts that its neighbour to the south, Buffalo, tends to receive. This, however, did not happen in January of 1999 and the extensive snowfall paralyzed the city for several days, shutting down transit systems and clogging the streets. To ensure emergency services, the Mayor of the GTA, Mel Lastman, brought in the army, no doubt inspired by their central role in effectively assisting during the Ice Storm of the previous year. This unfortunately brought much derision from those outside of the Toronto area. After all, many other areas of Canada receive comparable or more snowfall.

So then, how unusual was this month of snow? To examine this we look at Toronto's climatological record. The University of Toronto has been recording weather information since 1840, the longest continuous record in Canada, and one of the longest in the world. The mean annual snowfall for Toronto is 139.2 cm, 36.4 cm for January. This has been gradually declining. For example, the 1850s had an annual average snowfall of 186 cm while the 1980s had an annual snowfall of 120 cm. At the same time the percentage of total precipitation arising from snowfall has dropped from approximately 21% before 1900, to 17% for the period 1960 - 1990. In other words, Toronto winters have become rainier (and warmer). There have been five other months in Toronto's recorded history in which snowfall exceeded 100 cm. These are Feb. 1846 (117.1 cm), Jan. 1867 (106.7 cm), Feb. 1869 (100.8 cm), March 1870 (158.5 cm) and Jan. 1871 (110.7 cm). Thus January of 1999 was the snowiest January on record and the snowiest month during the 20th century but not the snowiest month on record. That honour goes to March of 1870. Note that the other snowy months occurred at least 128 years ago. No living Toronto resident has ever experienced the amount of snow in Toronto that fell last January. (However some will recall the 92.5 cm of December 1944 towards the end WWII).

Montréal, our sister city in Québec, is well known for its heavy snowfalls. How does Toronto stack up? Montreal has an average annual snowfall of 243 cm, almost twice more than Toronto. However, its most extreme month was February of 1960 with 132.2 cm, somewhat less than the Toronto peak of 158.5 cm. Thus, in its extremes, Toronto rates with the best of them.

William A. Gough, Environmental Science,
University of Toronto at Scarborough

Moira Dunbar, OC, FRSC

1918 - 1999

Moira Dunbar, a long-time friend and colleague of many CMOS members, passed away peacefully in the Queensway Carleton Hospital, Ottawa, ON, November 22, 1999. Moira is best known for her work on sea ice studies and aerial photo interpretation. She began her Arctic career with the Joint Intelligence Bureau and later with the Defence Research Board of Canada where she did much of her work on Arctic ice. Ms. Dunbar and Air Commodore Keith Greenaway co-authored the book *Arctic Canada from the Air.* It is a classic reference book of Arctic ice conditions as recorded and described from aerial photographs covering most if not all of the Canadian Arctic archipelago. Moira spent hundreds of hours flying in the Arctic and was one of the first women to have flown over the North Pole. She was not only an expert in aerial photo interpretation but also served as an ice observer and analyst aboard many Canadian icebreaker operations in the Arctic and Gulf of St. Lawrence. Her reputation was such that she served as an ice observer on the American ship *Manhattan*, a reinforced oil tanker that traversed the Northwest Passage.

Isobel Moira Dunbar was born in Edinburgh, Scotland in 1918 and graduated from Oxford University with an honours degree in geography in 1939. During the war she worked on the professional stage in Britain for seven years before coming to Canada in 1947. She was fluent in French, German and Russian and many of her best papers were published in the Russian scientific literature.

Moira was well recognized for her scientific work. She was an Officer of the Order of Canada, was awarded the Massey Medal, and was elected a Fellow of the Royal Society of Canada. She also served as a director of the Royal Canadian Geographical Society. Moira retired from the Public Service in 1978. She was predeceased by her brother, Maxwell John Dunbar, OC, FRSC, a long-time professor of marine biology and oceanography at McGill University.

Taken from the National Post and Globe and Mail.

Neil J. Campbell

Donald C. Archibald, OC

1906 - 2000

Donald C. Archibald passed away peacefully at his home in Toronto, on Tuesday, January 18, 2000 in his 94th year; beloved husband of Dr. A. Marguerite Archibald. Donald Archibald was a graduate of the University of Manitoba (M.Sc.) and Princeton University (M.A.). In 1930, he was appointed Superintendent, Western Airways Weather Forecasting Service where he established a meteorological reporting service for the air mail service in Western Canada. In 1933-34, he studied meteorology in Europe, mainly in Norway and in Germany, but also in Austria, Czechoslovakia, Italy and the U.K. He then trained meteorologists, organized the weather service and established offices in various cities in Western Canada for the air mail service from 1938 to 1943. For the war effort, he organized the weather service along the north-west staging route. From 1943 to 1946, he established, along with the U.S. Weather Bureau, the five joint arctic weather stations at Resolute, Eureka, Mould Bay, Isachsen and Alert - the most northerly land weather station in the world. In 1946, he was appointed Chief of the Basic Weather Service for Canada governing the surface weather stations and inspection services, and upper air, arctic and ice reconnaissance programs.

In 1971, he was awarded the Patterson Medal for distinguished service in meteorology, and retired as Chief, Basic Weather Services, Atmospheric Environment Service. On February 4,1998, Donald Archibald was appointed a Member of the Order of Canada.

The Hughes Memorial Symposium: A Tribute to the Legacy of Dr. Tertia M.C. Hughes, 1967-1998

The Centre for Climate and Global Change Research and the Department of Atmospheric and Oceanic Sciences, McGill University, would like to thank all those who attended and participated in the Memorial Symposium held at the McGill Faculty Club in remembrance of Dr. Tertia M.C. Hughes, on Tuesday, November 23, 1999. This event marked the first anniversary of her passing. Tertia Hughes completed both her M.Sc. and Ph.D. degrees in the Department of Atmospheric and Oceanic Sciences of McGill University in the early- to mid-1990s, and she had a close association with many of McGill's graduate students, faculty and staff until her tragic death in 1998.

Tertia was born in Ottawa, Ontario, on July 24, 1967 and grew up in Québec City, where she attended elementary and high school, CEGEP and first year of university

(Université Laval). She moved back to Ottawa in 1986, now fluently bilingual, and completed an honours B.Sc. in Mathematics and Physics at the University of Ottawa in 1989, for which she was awarded the Faculty of Science Silver Medal for academic excellence. This was followed by graduate studies on an NSERC scholarship in Atmospheric and Oceanic Sciences at McGill (M.Sc. 1991 and Ph.D. 1995). For both degrees she worked under the supervision of Dr. Andrew Weaver, who moved in 1992 to the School of Earth and Ocean Sciences at the University of Victoria, where Tertia also later lived and studied. In 1991, Tertia was awarded the Canadian Meteorological and Oceanographic Society (CMOS) Graduate Student Prize for her outstanding M.Sc. thesis. Following postdoctoral studies at the University of Victoria (1995-96), Tertia took up a Research Associateship at Princeton University in 1996 with Dr. Jorge Sarmiento. Tertia died in Woodstock, Ontario, on November 23, 1998, after struggling with an eating disorder (anorexia nervosa), aged 31.

At the Memorial Symposium, Dr. Andrew Weaver, Tertia's graduate supervisor, spoke about the ocean and climate research she carried out for her McGill theses, and subsequent developments which naturally followed from her work. It was clear soon after the commencement of Tertia's studies at McGill that her knowledge of atmospheric and oceanic sciences, as well as her analytical and quantitative skills, were well beyond that of the average M.Sc. student. She quickly progressed to the doctorate program at which time Dr. Weaver considered Tertia more as his colleague, rather than his student. They co-authored many publications on the stability and variability of the ocean thermohaline circulation and the role of the latter in climate. In many of these papers, Tertia did most of the work, but, she never wanted to take much of the credit. Tertia loved to be involved in the research-aspects of their joint investigations, but she did not like to be the centre of attention. She was not enthusiastic about making presentations, but when she did, Tertia excelled in this mode. This was Tertia's nature – quiet and understated. At the same time, she could be strong-willed and stubborn when she believed in something.

Dr. Jorge Sarmiento, from Princeton University's Program in Atmospheric and Oceanic Sciences, spoke about the close collaboration with Tertia during 1996-98, when she was a Research Associate in his laboratory. At Princeton, Tertia investigated the ocean carbon cycle and undertook research related to the role of the oceans in the uptake of atmospheric carbon dioxide in a warming climate due to the increase of anthropogenically-produced greenhouse gases in the atmosphere. She also was a major player in the development of the next generation of the Geophysical Fluid Dynamics Laboratory/NOAA coupled atmosphere-ocean climate model. Dr. Sarmiento read an excerpt from the letter of intent that Tertia composed when applying for the Princeton position. In this letter she described the research done in the past and the types of tests and analyses she was able to perform. She stated that "she hoped that she would be able to undertake the duties related to the position advertised". Professor Sarmiento discovered that not only was Tertia "able" to do as she had hoped, but also that she was able to do the work of several people as well. When the Associate Dean of the Faculty read Dr. Sarmiento's last evaluation of Tertia's work, he wanted to raise her salary even more than the high level that had already been recommended. This is but one example of the exceptional intelligence and innovation that Tertia brought to her profession. Dr. Sarmiento also reminisced on the numerous e-mail exchanges he had with Tertia, in which she brought humour to even the most tedious of tasks, such as when discussing the numerous revisions to a paper for publication in Nature.

Tertia had a unique sense of humour – she loved to share her thoughts and enjoyed hearing about travels abroad and learning about different cultures. Tertia gave of herself, both professionally and personally, apparently neither expecting nor wanting anything in return. She had a special blend of intelligence, integrity and humanity that made her a joy to work with, and be in her company. Her nine journal publications, which can be viewed at the http://wikyonos.seos.uvic.ca/people/hughes/pubs.html web site, are a testimony to Tertia's mark in science. That mark will always be remembered, and her smile will remain in the hearts of her colleagues and friends.

Short tributes at the Symposium were also made by the following personal friends and former colleagues:

- Dr. Charles Lin, Chair, Department of Atmospheric and Oceanic Sciences, McGill University;
- Dr. Nigel Roulet, Director, Centre for Climate and Global Change Research, McGill University;
- Ms. Vicki Loschiavo, former Administrative Officer, Department of Atmospheric and Oceanic Sciences, McGill University (who helped Tertia throughout her graduate student years at McGill);
- Dr. Bill Gough, Department of Environmental Science, Physical Sciences Division, University of Toronto (a former graduate student at McGill who overlapped with Tertia's earlier years there);
- Dr. Paul Myers, Department of Physics and Physical Oceanography, Memorial University of Newfoundland (a contemporary graduate student of Tertia's, both at McGill and later at the University of Victoria);
- Ms. Trudy Wohlleben, Department of Earth and Atmospheric Sciences, University of Alberta (an M.Sc. student at the University of Victoria when Tertia was there);

• Dr. Lawrence Mysak, Department of Atmospheric and Oceanic Sciences, McGill University (past founding Director of the Centre for Climate and Global Change Research, McGill University, and mentor and teacher of three graduate courses of Tertia's).

The profound impact made by Tertia, both in her personal and professional life, was the theme reiterated in all the tributes presented. Tertia touched the lives of all of those with whom she had contact, and she will be remembered for her dedication to her profession, her unfailing wit, her humility, and her interest and praise for the accomplishments of others.

Many distinguished guests attended the symposium, including Tertia's cousin, Dr. Heather Lewis, Dean of Social Science, Commerce, Arts and Letters at Vanier College, Montréal. Dr. Lewis later expressed in writing *her appreciation of the symposium,...and that she was particularly grateful for the personal reminiscences, e-mail excerpts and photos. It was important for people who knew Tertia in different contexts to get together and share memories*. Also in attendance were Dr. Ian Butler, Associate Vice-Principal (Research) at McGill, and Drs. Ian Rutherford and Neil Campbell, president and executive director, respectively, of the Canadian Meteorological and Oceanographic Society, which is based in Ottawa.

Tertia's scholarly accomplishments are numerous; a winner of many prestigious awards, she never lost her sense of intellectual curiosity and her desire to question and to learn, which are the mark of a true scholar. It is thus most fitting that the Canadian Meteorological and Oceanographic Society (CMOS) have renamed their graduate student prize the "Tertia M.C. Hughes Graduate Student Prize". The first such prize will be awarded in Victoria, B.C. in May 2000 at the annual CMOS Congress. The prize will include a financial award derived from the interest on contributions to a CMOS-SCMO endowment fund. Tax-deductible donations (payable to "CMOS - Tertia Hughes Memorial Fund"), are most welcome and can be addressed to: "CMOS - Tertia Hughes Memorial Fund", CMOS-SCMO, Suite 112, McDonald Building, University of Ottawa, 150 Louis Pasteur, Ottawa, ON, K1N 6N5.

Tertia Hughes will always be remembered, and we mourn her loss. However, it is with joy that we celebrate her life - she was an exceptional individual whose legacy will live on through the memories of all those she knew.

Dr. Lawrence A. Mysak and Angie Mansi
Centre for Climate and Global Change Research
McGill University

CONTRIBUTORS TO TERTIA HUGHES MEMORIAL FUND

Anonymous donation
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Total donations received to date: $10,700.00.

from Gordon McBean

Assistant Deputy Minister
Meteorological Service of Canada
(formerly Atmospheric Environment Service and Program -- AES/AEP)
Transition Bulletin No. 8, 20 December, 1999

As mentioned in the memo from the Deputy Minister, we have received the decision from Treasury Board Ministers on our submission. In this Bulletin, I will address each element of the decision and explain their impacts. I will also indicate the next steps to be taken in revitalizing the weather and environmental prediction programs.

A new identity

The issue of our identity had come up repeatedly during the renewal process. During ASD consultations, employees, clients and stakeholders said there was a need for a service that was a single entity. While preparing the Treasury Board submission, we also looked at how well the organization's name represents its work. We invited employees from NHQ and the regions to comment on several options for a new name.

Based on input from employees, and discussions with senior managers, there was Ministerial approval to change our name to the Meteorological Service of Canada (MSC) and in French, Service météorologique du Canada (SMC). This new name was incorporated into the Treasury Board submission. MSC becomes the single identification for all programs and services across Canada, whether they are in the regions or headquarters, and allows us to maintain the integrity of regional integration.

The image Environment Canada presents to the public is unchanged. "Environment Canada" will continue to be used as the main identification for services to the public, such as weather forecasts and warnings.

The MSC's mandate

The Treasury Board decision confirms the MSC as a national program with a clear mission, vision and mandate. With this confirmation, there is prominence to our mission and confirmation of the Ministerial priority of weather and environmental prediction. We are clearly an integral part of Environment Canada - a full member of the team that assists the Government of Canada in meeting its promise to deliver services through research and science that promote the health, safety and economic well-being of Canadians.

Now, MSC is officially the national institution with responsibility for weather forecasts and warnings, the national water survey, the ice service and science of the atmosphere, climate and air quality. As such, the work of MSC is as the principal scientific authority on the atmosphere, and related elements of the hydrosphere and cryosphere.

The goals of MSC are to apply meteorological and hydrological science to:

- Help save lives;
- Help avoid health risks;
- Help reduce property losses;
- Contribute toward the enhancement of economic productivity;
- Contribute toward the adoption of the best environmental policies.

New ways of working

Treasury Board has increased our contracting authority to $4 million from $1 million. This is the highest authority granted to departments other than Public Works and Government Services Canada. This increased flexibility means we can enter into larger contracts and have more efficient administration of those contracts. We can also retain proceeds from the sale of capital assets, making it possible for us to start rejuvenating our infrastructure. There is also approval for us to set up a procedure for entering into capital lease-back arrangements with the private sector. This will allow us to operate in a more businesslike manner. Through the provision for carry-forward capital funding appropriations, we will be able to operate more efficiently.

The implementation of a cost recovery framework will bring clarity and consistency in the delivery of cost recovered services. In providing those services and products, the MSC will give due consideration to the public policy reasons for doing so, and to being consistent with its mandate. It will ensure that the full costs of the activity are recovered, and that it is competing fairly with private sector suppliers in terms of its costing and pricing mechanisms, and its access to data. Lastly, the MSC will look for ways to foster partnering arrangements with the Canadian private sector to develop commercial meteorological services.

The MSC will also be involved in a pilot project to test Activity-Based Costing as a tool to help us determine exactly what it costs us to provide our services and find ways to operate more efficiently.

Next steps

I know that many of you were looking to the Treasury Board submission to address other long-standing issues. I want to emphasize that this is an initial step, and not the final one, in revitalizing the Service. The submission succeeded in doing certain things: it made the Board aware of our critical human resources needs, financial shortfall and our aging infrastructure; and it outlined the kinds of authorities we need to continue providing high quality science and service. While the Board can't respond to these needs right now, it will work with us to find long-term funding and help us meet our goals.

Strategic directions

It was the MSC Treasury Board submission that put the "rusting out" issue on the federal agenda. MSC is one of the priorities under the central Program Integrity Exercise. Treasury Board is using this Exercise to examine all aspects of government infrastructure, and MSC is assured its needs are being considered along with those of other departments.

Environment Canada considers the MSC a priority and has made $5.3 million available in this fiscal year to the Service to address its most pressing human resources and infrastructure issues. Managers have assigned priorities in these areas and projects and recruitment of new meteorologists are under way.

We will continue to seek solutions on the rusting out issue, and others, by talking to Environment Canada management, staff, clients and stakeholders. We have identified several priorities for action:

- replace obsolete equipment and create a life cycle management system;
- work with other agencies to develop standards for atmospheric and hydrometric data, observing systems, practices and methods;
- work toward further renewal and revitalization of the Service;
- evaluate the opportunity to seek legislation to make the MSC Canada's official source for weather warnings where public safety is at stake;
- optimize service delivery through specialized centres located, staffed and equipped to meet the needs of the public and our major partners and clients;
- improve the services we provide to the public and major clients in aviation and marine weather;
- use new technologies to give Canadians direct access to information at a lower cost, seek new types of cooperative arrangements with private companies, and encourage the development of private sector capacity while increasing our own presence in communities;
- work with research partners to improve the detection and prediction of extreme weather;
- seek university and private sector partners to create research opportunities that increase Canada's capacity in atmospheric and hydrologic science; and
- develop partnerships with Universities to strengthen meteorological programs in Canada.

Human resources

The MSC wants to regain the capacity to attract and retain highly skilled employees as it did in the past. To that end, we will seek funding and partnerships to:

- launch a national recruitment program for meteorologists and atmospheric and hydrometric technicians;
- develop continuous learning programs for employees;
- develop strategies to ensure the MSC has the employees it needs in critical areas in the future;
- improve safety and health conditions in the field.

For more information

An employee fact sheet outlining these changes will soon be available on the Intranet and in Environment Canada offices. If you have any questions, please contact your manager or send them to me by e-mail. I will continue to keep you up-to-date and deal with concerns in future editions of the Transition Bulletin.

Watch for future issues of the Transition Bulletin, as we devote entire issues to these main topics: our mandate, the Cost Recovery Framework and our name and identity.

In closing, I would like to thank the many people who worked on this phase of our transition. I would also like to thank employees for the information and insights they have provided during this renewal process.

Gordon McBean

ADM, Meteorological Service of Canada

de Gordon McBean

Sous-ministre adjoint

Service météorologique du Canada

(anciennement Service/Programme de l'environnement atmosphérique – SEA/PEA)

Bulletin en transition no 8,

le 20 décembre 1999

Comme indiqué dans la note du sous-ministre ci-jointe, nous avons reçu la décision des ministres du Conseil du Trésor concernant notre présentation. Dans ce Bulletin, je me pencherai sur chacun des éléments de la décision et j'en expliquerai les répercussions. J'indiquerai également les prochaines étapes à suivre pour revitaliser les programmes de prévision météorologique et environnementale.

Une nouvelle identité

La question de notre identité a souvent fait surface au cours du processus de renouvellement. Lors des consultations sur les nouveaux modes de prestation de services, les employés, les clients et les intervenants ont fait état de la nécessité d'un service donnant l'image d'une seule entité. Lors de la préparation de la présentation au Conseil du Trésor, nous avons analysé dans quelle mesure le nom de l'organisation décrit bien son travail. Nous avons invité les employés de l'administration centrale et des régions à formuler des commentaires sur plusieurs choix de noms.

Sur la base de l'apport des membres du personnel et des discussions avec les cadres supérieurs, nous avons reçu l'autorisation ministérielle d'adopter le nom de Service météorologique du Canada (SMC) / Meteorological Service of Canada (MSC). Ce nouveau nom était également mentionné dans la présentation au Conseil du Trésor. Il devient l'identité unique pour l'ensemble des programmes et des services, partout au pays, qu'ils soient assurés dans les régions ou à l'administration centrale et nous permet de préserver l'intégrité de l'intégration régionale.

L'image publique d'Environnement Canada ne change pas. "Environnement Canada" continuera à être le dénominateur générique des services au public, comme les prévisions, les avertissements et les alertes météorologiques.

Le mandat du SMC

La décision du Conseil du Trésor confirme que le SMC est un programme national comprenant une mission, une vision et un mandat précis. Grâce à cette confirmation, notre mission devient bien visible et se traduit par la confirmation des priorités ministérielles dans le domaine de la prédiction météorologique et environnementale. Il est clair que nous faisons partie intégrante d'Environnement Canada, un membre à part entière d'une équipe qui aide le gouvernement du Canada à livrer, comme promis, grâce aux recherches et aux sciences, des services favorisant la santé, la sécurité et le bien-être économique de la population canadienne.

Maintenant, le SMC est l'institution nationale officielle ayant la responsabilité des prévisions et avertissements météorologiques, des relevés hydrologiques du Canada, du service des glaces, de la science de l'atmosphère et climatique, et de la qualité de l'air. En ce sens, le travail du SMC est donc celui de la principale autorité scientifique dans le domaine atmosphérique et en ce qui concerne les éléments connexes de l'hydrosphère et de la cryosphère.

Les objectifs du SMC consistent à appliquer les principes scientifiques de la météorologie et de l'hydrologie pour:

- aider à sauver des vies;
- aider à éviter des risques pour la santé;
- aider à réduire les pertes de biens;
- contribuer à améliorer la productivité économique;
- contribuer à l'adoption de meilleures politiques environnementales.

De nouvelles façons de travailler

Le Conseil du Trésor a accru notre limite de passation de contrats de un à quatre millions de dollars. Il s'agit de la limite la plus élevée accordée à un ministère autre que Travaux publics et Services gouvernementaux Canada. Cette plus grande souplesse signifie que nous allons pouvoir passer des contrats plus importants et administrer ces contrats de façon plus efficace. Nous pourrons également conserver les recettes de la vente d'éléments d'actif, ce qui nous permettra de commencer à mettre à jour nos infrastructures. Nous avons reçu l'autorisation d'établir un processus permettant de passer des contrats de cession-bail avec le secteur privé. Cela nous permettra de fonctionner davantage comme une entreprise privée. Nous pourrons aussi fonctionner plus efficacement grâce à l'autorisation de reporter les crédits en vue du financement d'immobilisations.

La mise en œuvre d'un cadre de recouvrement des coûts permettra d'appliquer des modalités claires et cohérentes dans ce domaine. En offrant ces services et ces produits, le SMC tiendra compte, comme il se doit, de l'intérêt public tout en respectant son mandat. Il veillera au recouvrement de l'ensemble des coûts de ses activités et il s'adonnera à une concurrence juste avec les fournisseurs du secteur privé aux niveaux de la détermination de ses coûts et du prix de ses services et produits, ainsi que de l'accès aux données. Enfin, le SMC cherchera des façons de conclure des accords de partenariat avec le secteur privé canadien pour développer des services météorologiques commerciaux.

Le SMC participera également à un projet pilote pour mettre à l'essai la comptabilité par activités comme outil nous permettant de déterminer avec précision ce qu'il nous en coûte pour offrir nos services, et pour trouver des façons plus efficaces de fonctionner.

Nouvelles étapes

Je sais que plusieurs espéraient que la présentation au Conseil du Trésor aborderait d'autres problèmes latents depuis longtemps. Je tiens à préciser qu'il ne s'agit ici que d'une première étape – et non pas de la dernière – pour revitaliser le service. La présentation a atteint certains objectifs : elle a sensibilisé le Conseil du Trésor à nos besoins pressants en ressources humaines, aux problèmes sérieux de notre déficit et de notre infrastructure vieillissante et elle a précisé le type de pouvoirs dont nous avons besoin afin de poursuivre notre travail scientifique et de fournir des services de haute qualité. Si le Conseil du Trésor ne peut répondre immédiatement à tous nos besoins, il collaborera avec nous pour trouver des solutions de financement à long terme et pour nous aider à atteindre nos objectifs.

Les orientations stratégiques

Cette présentation au Conseil du Trésor sur le SMC a été à l'origine de l'inscription à l'ordre du jour du gouvernement fédéral de la nécessité de surveiller le vieillissement des infrastructures. Le SMC est une priorité dans le cadre de l'exercice central d'intégrité des programmes. Le Conseil du Trésor a recours à cet exercice pour étudier tous les aspects de l'infrastructure gouvernementale et le SMC est ainsi assuré que ses besoins font l'objet d'une étude attentive, tout comme ceux des autres ministères.

Environnement Canada considère que le SMC est une priorité et met une somme de 5,3 millions de dollars au cours du présent exercice financier pour répondre à ses besoins les plus pressants en matière de ressources humaines et d'infrastructure. Les gestionnaires ont défini les priorités dans ces secteurs et divers projets ainsi que le recrutement de nouveaux météorologues ont été enclenchés.

En parlant avec les gestionnaires, le personnel, les clients d'Environnement Canada et avec les autres intervenants, nous continuerons à chercher des solutions pour répondre à ses besoins de rajeunissement. Nous avons cerné plusieurs priorités:

- remplacer l'équipement périmé et se doter d'un système de gestion du cycle de vie;
- collaborer avec d'autres organismes pour élaborer des normes concernant les données atmosphériques et hydrométriques pour les systèmes, les pratiques et les méthodes d'observation;
- travailler à poursuivre le renouveau et la revitalisation du Service ;
- évaluer la possibilité de recourir à la législation pour faire du SMC la source officielle, au Canada, des avertissements et des alertes météorologiques quand la sécurité du public est en jeu;
- optimiser la prestation de services grâce à des centres spécialisés dotés en personnel et en équipement et situés aux endroits voulus pour répondre aux besoins du public, de nos partenaires et de nos clients importants;
- améliorer les services que nous offrons au grand public et aux clients importants dans le domaine des prévisions pour l'aviation et la marine;
- utiliser les nouvelles technologies pour permettre aux Canadiens et Canadiennes d'accéder à l'information à un faible coût; chercher de nouveaux types d'accords de coopération avec des entreprises privées, et favoriser le développement de la capacité du secteur privé tout en augmentant notre propre présence dans les collectivités;
- travailler avec les partenaires de la recherche pour améliorer la détection et les prévisions de situations météorologiques extrêmes;
- chercher des partenaires dans les milieux universitaires et privés pour trouver des possibilités de recherche qui permettront d'accroître la capacité du Canada dans les domaines scientifiques de l'atmosphère et de l'hydrologie; et
- élaborer des partenariats avec les universités pour renforcer les programmes météorologiques au Canada.

Ressources humaines

Le SMC veut recouvrer la capacité qui était la sienne auparavant, d'attirer et de conserver des employés hautement compétents. À cette fin, nous allons demander des fonds et constituer des partenariats pour:

- lancer, à l'échelle nationale, un programme de recrutement de météorologues et de techniciens dans les domaines de l'atmosphère et de l'hydrométrie;

- mettre en place des programmes de formation continue pour les employés;
- élaborer des stratégies pour s'assurer que le SMC dispose des employés dont il a besoin dans les domaines essentiels pour l'avenir; et
- améliorer les conditions touchant à la sécurité et à la santé sur le terrain.

Complément d'information

Une fiche d'information pour employés présentera ces changements et sera offert sous peu sur le réseau interne et dans les bureaux d'Environnement Canada. Si vous avez des questions, posez-les à votre gestionnaire ou envoyez-les-moi par courriel. Je continuerai à vous tenir informés et à répondre à vos diverses préoccupations dans les éditions ultérieures du Bulletin en transition.

Surveillez la publication des prochains numéros du Bulletin en transition car nous allons consacrer des numéros spéciaux à plusieurs grands sujets dont notre mandat, le cadre de recouvrement des coûts, notre nom et notre identité.

Pour terminer, je tiens à remercier toutes les personnes qui ont collaboré à cette phase de notre transition. Je tiens également à remercier les employés des informations qu'ils nous ont transmises et de leur apport pendant ce processus de renouvellement.

Gordon McBean

SMA, Service météorologique du Canada

PROJECT ATMOSPHERE - 1999

As a song in the musical Oklahoma says *"Everything is up to date in Kansas City"* and this was certainly the case for this year's Project Atmosphere. This summer institute was held in the newly opened National Weather Service (NWS) Training Centre in Kansas City and brought together twenty-six teachers, including three South Africans, one Mexican and myself, to experience an intense two-week period of instruction, field trips, discussion and classroom work. The NWS flew in a number of highly respected specialists from around the United States, in the fields of hurricanes, severe weather, remote sensing and weather modelling, to allow us to meet with them, question and learn about the newest ideas and directions that weather and weather forecasting is heading. We also benefitted from a Project Atmosphere alumnus from a previous year and several other college and NWS instructors as they either introduced new concepts or refreshed our knowledge in exciting and interesting ways. We had many opportunities to see and make use of the *'latest and greatest'* weather instruments, computers and resources located in the NWS Training Centre. The speed and capabilities of their extensive computer systems and instrumentation would make any teacher quite envious. One exciting discovery I made was that much of the data, projections and maps from this computer network, are easily available over the Internet.

Project Atmosphere has developed an extensive range of lesson ideas, teaching aids, videos and resources that can be used directly in your classroom, adapted for your specific use or to serve as teacher learning materials. Over the course of the two weeks I sampled all of these resources, worked through the accompanying activities, studied the videos and amassed an amazing amount of experiences and paraphernalia which I now treasure. Now that I have returned to Ontario I will be available to use this material and experiences to conduct workshops for schools and school districts and to pass on some of the teaching ideas I discovered in Kansas City.

I want to thank the Canadian Council for Geographic Education (CCGE) and CMOS for their financial support by covering my transportation to Project Atmosphere. This is a very tangible display of the value these organizations put on quality professional development and I am truly grateful that I was selected to attend. I hope now to demonstrate in some measure my gratitude through future articles in this publication and forthcoming workshops.

Project Atmosphere will be repeated again in late July 2000. If you would like any further information about the summer institute or about possible workshops in your district, I hope you will contact me at:

Michael Ball,

Program Facilitator - Social Sciences

Durham District School Board

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Brian Nicholls Retires

Secretary, CNC/SCOR/ECOR, 1985-1999

Brian Nicholls was appointed Secretary of the Canadian National Committees (CNCs) for SCOR and ECOR in 1985. At the time he was employed by the Department of

Fisheries and Oceans (DFO) at the Bedford Institute of Oceanography (BIO), Dartmouth, NS, and he assumed the duties of CNC Secretary in addition to his other responsibilities as Head of the Ocean Information Division. Previously the CNC Secretariat had been located at DFO Headquarters, Ottawa, where Leo O'Quinn was the Secretary. Brian served as Secretary until his retirement from the federal public service in July 1997, at which time he was Head of DFO Maritime Region's Environmental Assessment Section. Shortly after retiring, he was invited to return as part-time secretary on an acting basis until a new permanent arrangement could be put in place. This acting appointment continued until December, 1999.

As Secretary of the two CNCs, Brian served under the following chairpersons (listed in chronological order):

CNC/SCOR

- Prof. Bruno d'Anglejan, McGill University;
- Dr. Mike Waldichuck, DFO, West Vancouver Laboratory;
- Dr. Jeff Thompson, DFO, Institute of Ocean Sciences;
- Prof. Louis Hobson, University of Victoria;
- Dr. Ken Lee, DFO, Institut Maurice Lamontange.

CNC/ECOR

- Mr. John Brooke, Brooke Ocean Technology Ltd., Dartmouth, NS;
- Dr. David Ross, GSC (Atlantic), Bedford Institute of Oceanography;
- Mr. Ray Mills, Whitman Benn and Associates Ltd., Halifax, NS;
- Prof. Jacques Locat, Université de Laval;
- Dr. Charles Schafer, GSC (Atlantic), Bedford Institute of Oceanography.

The Secretary of the CNCs is responsible for correspondence, records, meetings, interaction with SCOR and ECOR, international and interaction with DFO and NRC, external liaison, internal communication, and public relations. Brian attended all meetings of the two national committees during his fourteen-year term, as well as several meetings of the corresponding international bodies. Both SCOR and ECOR held full international meetings in Canada which involved him in their organization. In addition to serving the two CNCs, Brian assisted both international organizations in a variety of other ways: serving on an ad hoc SCOR group to consider the future of the Joint Oceanographic Assembly conference series; and as ECOR treasurer. He was also appointed an Associate Editor of the ECOR journal Oceanic Engineering International in 1997.

Brian has served the oceanographic community at large for these many years and we are all indebted to him for his many years of service. Thank you Brian.

Neil Campbell, Executive Director

Appointment of a new Secretary for CNC/SCOR/ECOR

Paul-André Bolduc has taken on additional responsibilities for CMOS as the new Secretary for the Scientific Committee on Oceanic Research (SCOR) and the Engineering Committee on Ocean Resources (ECOR). André takes over from Brian Nicholls, now retired but formerly an Executive Assistant and Science Policy Advisor to the Director of the Bedford Institute of Oceanography. Brian served as Secretary to SCOR/ECOR for 14 years (see "Brian Nicholls Retires" on page 26 in this Bulletin).

CMOS was invited by DFO to assume the responsibility for the secretariat of SCOR/ECOR and, with Paul-André joining the CMOS office on his retirement, the SCOR/ECOR functions will be run from the Executive Director's office. Brian Nicholls will continue as a special advisor and consultant to CMOS on SCOR/ECOR matters.

Paul-André has just retired from DFO but will remain close at hand continuing with his editorship of the CMOS Bulletin SCMO from DFO Headquarters. He brings a wealth of experience to us, in addition to his editorship of the Bulletin. André has served the DFO for over thirty years as Chief of Tides and Water Levels, Chief of Data Management and User Services and in his outgoing capacity as Chief of Scientific Data Support. Paul-André has also been involved in Policy and Program Review and as a member of the DFO Science Subvention Program.

He holds several degrees, graduating first with a BA from the Université de Montréal in 1963, and in 1968 from École Polytechnique with a Bachelor of Applied Sciences in Civil Engineering. Paul-André also holds Masters degrees in Hydrology and Public Administration. He is professionally associated with the "Ordre des ingénieurs du Québec", "Association des diplômes de Polytechnique" and, of course, CMOS.

Paul-André has served as editor of the CMOS Bulletin SCMO for the past four years and also 'way back in 1983-1985 as associate editor then editor of the Newsletter. We welcome his continued and expanded role in CMOS.

Neil Campbell, Executive Director

Brian Nicholls prend sa retraite
Secrétaire, CNC/SCOR/ECOR, 1985-1999

Brian Nicholls a été nommé secrétaire des comités nationaux canadiens (CNC) de SCOR et ECOR en 1985. À l'époque, il était à l'emploi du ministère des Pêches et des Océans (MPO) à l'Institut océanographique de Bedford, à Dartmouth, N.-É., où il occupait le poste de secrétaire des CNC, en plus de ses autres tâches en tant que chef de la division de l'information océanique. Auparavant, le secrétariat des CNC était situé au siège social du MPO, à Ottawa, et Leo O'Quinn en était le secrétaire. Brian en a été le secrétaire jusqu'à sa retraite de la fonction publique fédérale en juillet 1997, alors qu'il était chef de la section de l'évaluation environnementale, région des Maritimes, pour le MPO. Peu de temps après avoir pris sa retraite, on lui a proposé de réintégrer le poste de secrétaire à temps partiel, à titre intérimaire, jusqu'à ce qu'une permanence soit mise en place. Cette nomination par intérim se prolongea jusqu'en décembre 1999.

En tant que secrétaire des deux CNC, Brian a travaillé pour les présidents suivants (en ordre chronologique):

<u>CNC/SCOR</u>

- Prof. Bruno d'Anglejan, Université McGill;
- Dr Mike Waldichuck, MPO, Laboratoire de Vancouver ouest;
- Dr Jeff Thompson, MPO, Institut des sciences de la mer;
- Prof. Louis Hobson, Université de Victoria;
- Dr Ken Lee, MPO, Institut Maurice-Lamontagne.

<u>CNC/ECOR</u>

- M. John Brooke, Brooke Ocean Technology Ltd., Dartmouth, N.-É.;
- Dr David Ross, GSC (Atlantique), Institut océanographique de Bedford;
- M. Ray Mills, Whitman Benn and Associates Ltd., Halifax, N.-É.;
- Prof. Jacques Locat, Université Laval;
- Dr Charles Schafer, GSC (Atlantique), Institut océanographique de Bedford.

Le secrétaire des CNC a la responsabilité de la correspondance, des dossiers, des réunions, de l'interaction avec SCOR et ECOR, de l'interaction internationale avec le MPO et le CNRC, des liaisons externes, des communications internes et des relations publiques. Durant son mandat de quatorze ans, Brian a participé à toutes les réunions des deux comités nationaux, ainsi qu'à plusieurs réunions des organismes internationaux correspondants. SCOR et ECOR, qui tenaient tous deux des rencontres internationales au Canada, l'impliquaient dans l'organisation de leurs rencontres. En plus de travailler pour les deux CNC, Brian aidait les deux organismes internationaux de plusieurs autres façons: il siégeait à un groupe ad-hoc de SCOR afin d'examiner l'avenir des séries de conférences de l'Assemblée océanographique commune et il était le trésorier de ECOR. Il fut également nommé en 1997 rédacteur en chef adjoint de la revue de ECOR Oceanic Engineering International.

Brian a servi la communauté des océanographes pendant de nombreuses années et nous lui somme tous reconnaissants pour toutes ses années de loyaux services.

Merci Brian.

Neil Campbell, Director exécutif

Nomination d'un nouveau Secrétaire au CNC/SCOR/ECOR

Paul-André Bolduc a accepté une nouvelle tâche pour la SCMO, celle de secrétaire du Comité scientifique de la recherche océanographique (SCOR) et du Comité de l'ingénierie des ressources océaniques (ECOR). Paul-André remplace Brian Nicholls, maintenant à la retraite, mais qui occupait autrefois les postes d'adjoint exécutif et de conseiller en politiques scientifiques pour le directeur de l'Institut océanographique de Bedford. Brian a déjà occupé le poste de secrétaire de SCOR/ECOR pendant quatorze ans (voir "Brian Nicholls prend sa retraite" à la page 27 de ce Bulletin).

Le MPO a demandé à la SCMO de prendre en charge le secrétariat de SCOR/ECOR et, grâce à la participation de Paul-André qui se joint au bureau de la SCMO pendant sa retraite, les tâches de SCOR/ECOR seront menées directement du bureau du directeur exécutif. Brian Nicholls continuera en tant que conseiller spécial pour la SCMO pour les questions se rapportant à SCOR/ECOR.

Paul-André vient tout juste de prendre sa retraite du MPO, mais demeurera étroitement lié grâce à sa responsabilité éditoriale au Bulletin SCMO à partir des bureaux du MPO.

Il apporte avec lui une vaste expérience, en plus de celle qu'il détient déjà en rédaction du Bulletin. Paul-André a travaillé pendant plus de trente ans au MPO en tant que Chef, Marées et Niveaux d'eau, Gestion des données et services aux usagers et, avant son départ, comme Chef, Soutien aux données scientifiques. Paul- André s'est également impliqué dans les politiques et revision de programme et en tant que membre du programme de financement des sciences du MPO.

Paul-André est titulaire de plusieurs diplômes, dont un B.A. de l'Université de Montréal, obtenu en 1963, et un baccalauréat ès sciences appliquées en génie civil de l'École Polytechnique, en 1968. Il détient également deux maîtrises, dont une en hydrologie et l'autre en administration publique. Il est membre de l'Ordre des ingénieurs du Québec, de l'Association des diplômés de Polytechnique et, bien sûr, de la SCMO.

Paul-André est rédacteur du CMOS Bulletin SCMO depuis quatre ans, en plus d'avoir été, entre 1983 et 1985, rédacteur adjoint, puis rédacteur du Bulletin de nouvelles de la SCMO. Nous l'accueillons avec enthousiasme dans son nouveau mandat, et saluons son apport continu.

Neil Campbell, Directeur exécutif

Report of the Nominating Committee
Rapport du Comité de mise en candidature

Members/membres:

John D.Reid ; Peter Taylor;

Bill Pugsley (Chair/Président)

The Committee nominates the following persons for the 2000-01 Council. All nominees have expressed their willingness to serve in the indicated positions.

Le comité met en nomination les personnes suivantes pour faire partie du Conseil d'administration pour l'année 2000-01. Toutes les personnes mises en nomination ont consenti à occuper les postes indiqués.

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(submitted January 22, 2000; présenté le 22 janvier 2000).

SEAFOOD SUSTAINABILITY IN A CHANGING CLIMATE

in the Northeast Pacific Ocean and Coastal Zones

A participatory workshop to develop solutions and recommendations for policy and research to sustain the fisheries during anticipated climate change:

- wild fisheries;
- finfish aquaculture;
- shellfish aquaculture.

May 25-26, 2000
University of Victoria, Victoria, BC

We encourage a wide range of researchers, policy-makers and, most especially, those directly involved in the various facets of the fisheries and aquaculture business to share their knowledge, learn about the possible impacts of climate change, and to assist in developing recommendations for future research and policy.

For more information and to register please consult the workshop website at:

www.cics.uvic.ca/workshop

We look forward to seeing you there ... bring your ideas!

Contact: Rick Lee
rjlee@uvic.ca
Tel: (250) 472-4291 Fax: (250) 721-7217

Marine Remote Sensing Applications Workshop Announcement

C-CORE, with support from the Canada Centre for Remote Sensing, will be hosting a Workshop on Marine Remote Sensing Applications, to be held in St. John's, Newfoundland on Monday, June 19, 2000.

The goal of the Workshop is to bring together representatives from marine-based industries with remote sensing service providers who offer the potential of improved monitoring, understanding, and prediction of the marine environment. The remote sensing technologies are not restricted and include satellite, marine, airborne and land based radar systems, optical (including infrared) and acoustic sensing. Presentations will be given by potential end users of remotely sensed marine data and working sessions will be organized to develop strategies to address these, and other data requirements.

It is intended that service providers will gain insight into the real needs of the marine operators and the value of required information, and will identify new markets and opportunities. Operators or end users benefit from having remote sensing experts providing solutions to facilitate greater efficiency. There will also be an opportunity to discuss broadening and improving remote sensing products through the integration of data from various sensors.

For more information or to be included on the Workshop mailing list, please contact Sherry McHugh at (709) 737-4313 or email smchugh@morgan.ucs.mun.ca

5th Annual Northern Plains Convective Workshop

Winnipeg, Manitoba, Canada
April 25-27, 2000

The Northern Plains Convective Workshop focuses on topics related to convective weather over the Northern Plains. This workshop arose out of the desire of Northern Plains Weather Centers and Universities to address the need to improve the understanding and forecasting of northern plains convection (in particular, as it relates to Severe Weather). The first four workshops were held in the U.S. and this year, for the first time, the workshop will be held in Canada.

The Environment Canada's Meteorological Service of Canada has participated in most of these workshops. This year Environment Canada's Prairie Storm Prediction Centre in Winnipeg, along with the Canadian Meteorological and Oceanographic Society and the University of Winnipeg (final approval pending) will host this year's event. The workshop is open to federal, provincial, state, municipal, and private agencies, researchers/professors, students (undergrad and graduate), and anyone interested in convective weather or related warning preparedness. There may be a small registration fee (no more than $10 US per person).

Call for Papers

This workshop provides an opportunity to share ideas, new concepts and approaches, new techniques, hardware and software through presentations and hands-on workshops. Persons interested in presenting have the freedom to chose between an oral or hands-on presentation.

This year the Workshop's theme will be "Severe Weather Preparedness". We are pleased to announce that Al Moller, NWS senior meteorologist from Fort Worth - Dallas will be this year's keynote speaker. However, this workshop will still focus on a broad range of convective weather topics (including research), particularly those that relate to operational forecasting. Suggested topics for presenters include:

- Summer Severe Thunderstorms
- Tornadoes
- Hail
- Severe Winds
- Flash Flooding
- Lightning
- Severe weather forecasting - techniques and tools
- Weather modification
- Convective processes
- Convective processes and large scale flooding
- Severe winter convective processes
- Weather radar applications
- Satellite applications
- Warning preparedness
- Warning dissemination

If you are interested in presenting, please send your expression of interest and/or abstracts (electronic versions preferred - MS WORD recommended) by March 22, 2000 to:

Jay.Anderson@ec.gc.ca
Tel: (204) 984-6389; Fax: 204-983-0109

If you have further questions, are interested in attending, or would like an information package (including hotel, etc. information) mailed to you, please contact:

Patrick.McCarthy@ec.gc.ca
Tel: (204) 983-1904; Fax: (204) 983-0109

Pat McCarthy
Severe Weather Program Manager
Prairie Storm Prediction Centre
Winnipeg, Manitoba, Canada

34th Annual CMOS Congress

Student Travel Bursaries to Victoria, B.C. Last date for submitting application is April 1, 2000

Graduate students interested in attending the Congress, should consider submitting an online application for a Congress Travel Bursary. Approximately $5000 is allocated each year to support students up to $500 each.

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

Requirements

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

2. The student must submit a suitable abstract for a presentation at the Congress.

Note: A student who is current recipient of CMOS Graduate Student Prize, or the holder or awardee of a CMOS Scholarship, qualifies for Travel Bursary provided he/she submits a suitable abstract and the application for the Travel Bursary.

To obtain an Application Form turn to the CMOS Web page and click on **Student Bursaries**.

34e Congrès annuel de la SCMO

Bourses de voyage pour étudiants pour Victoria, C.-B. Date limite de remise de la demande: 1er avril 2000

Les étudiants diplômés intéressés à participer au Congrès de la SCMO peuvent soumettre une demande électronique pour une bourse de voyage pour le Congrès. Environ 5 000 $ sont remis chaque année afin d'aider les étudiants, qui reçoivent chacun un montant de 500 $.

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

Exigences:

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

2) L'étudiant doit préparer un résumé approprié pouvant être présenté au Congrès.

Note: Le récipiendaire du Prix de l'étudiant diplômé de la SCMO de cette année, ainsi que le récipiendaire actuel d'une bourse de la SCMO, sont également admissibles pourvu qu'ils ou elles présentent un résumé approprié et une demande de bourse de voyage.

Pour obtenir un formulaire d'inscription, veuillez voir le site Web de la SCMO et cliquer sur " Bourses pour étudiants ".

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 2000. 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 24 - August 4, 2000 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. 28, No. 1, p. 25). 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 2000. 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 24 juillet au 4 août 2000 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. 28, No. 1, p. 25). 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; Télécopie: (613) 993-4658
Courriel: cmos@meds-sdmm.dfo-mpo.gc.ca

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 2000.

Neil J. Campbell,
Directeur exécutif

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 2000.

Neil J. Campbell
Executive Director

CMOS-ACCREDITED CONSULTANTS
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Mory Hirt

Applied Aviation & Operational Meteorology

Meteorology and Environmental Planning
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Ian J. Miller, M.Sc.
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Météomédia / The Weather Network
1755, boul. René-Levesque Est, Suite 251
Montréal, Québec, H2K 4P6 Canada
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4064 West 19th Avenue
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112 Varsity Green Bay NW
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E-mail: thompsow@cadvision.com

CANADIAN METEOROLOGICAL AND OCEANOGRAPHIC SOCIETY
LA SOCIÉTÉ CANADIENNE DE MÉTÉOROLOGIE ET D'OCÉANOGRAPHIE

112-150 Louis Pasteur, Ottawa, ON K1N 6N5
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E-mail - Courriel: cap@physics.uottawa.ca
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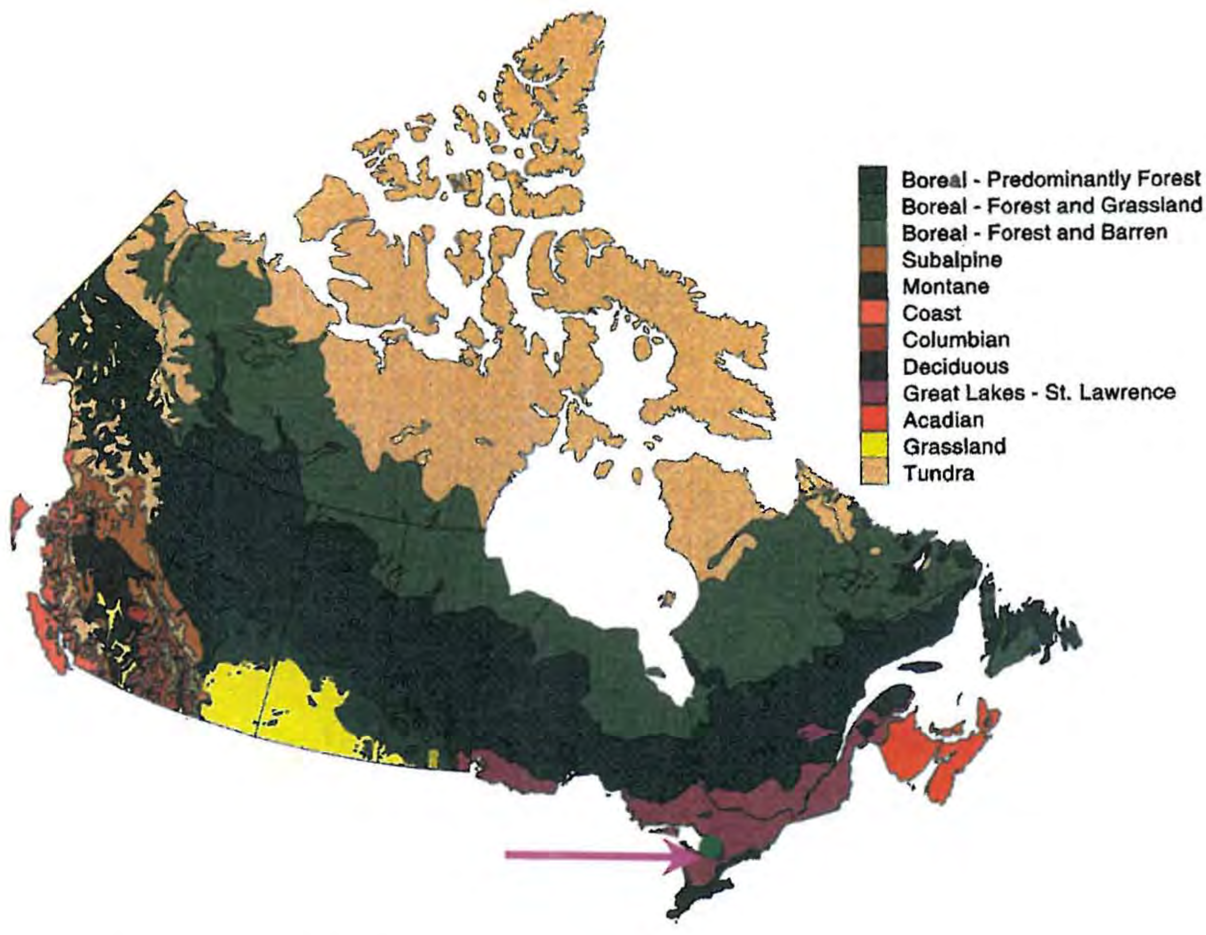

Figure 1. Location of the Borden forest and associated vegetation throughout Canada.