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Canadian Meteorological and Oceanographic Society

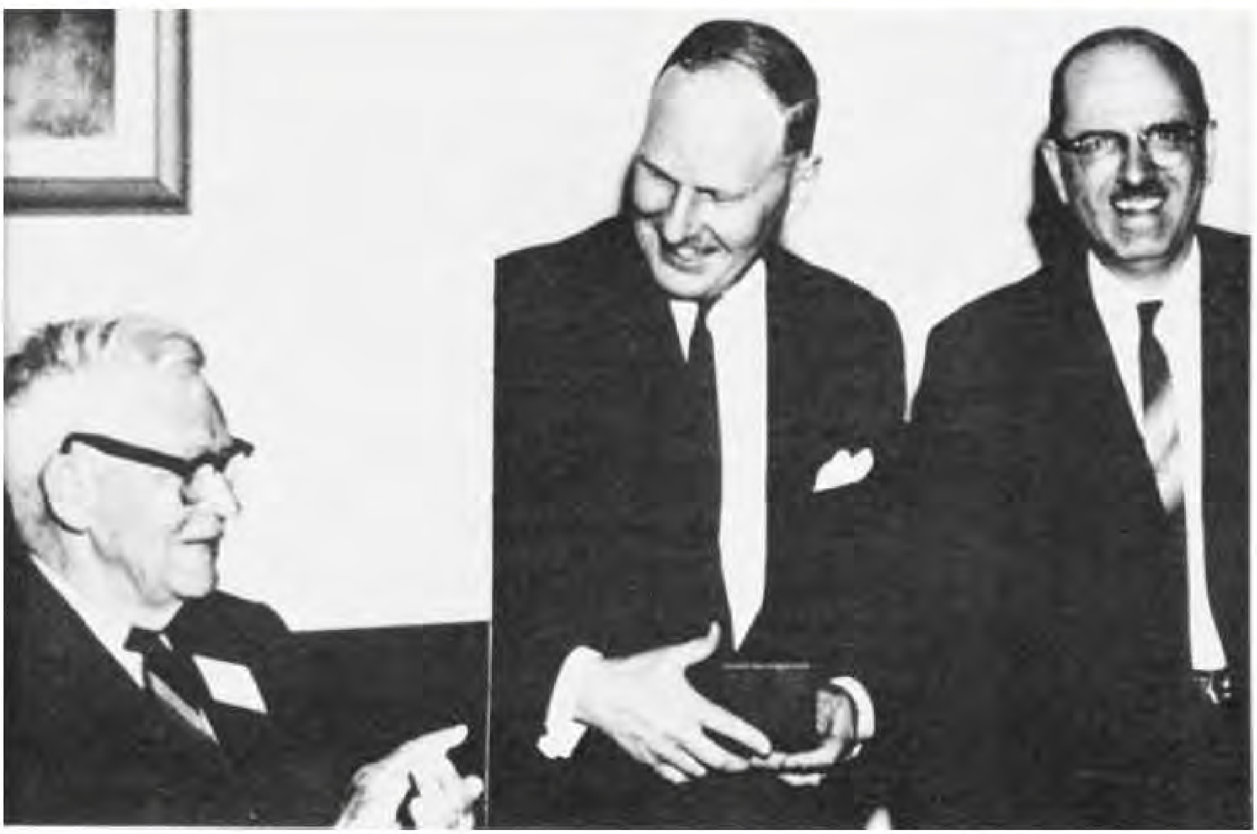
La Société canadienne de météorologie et d'océanographie

# CMOS BULLETIN SCMO

April / avril 2016 Vol.44 No.2

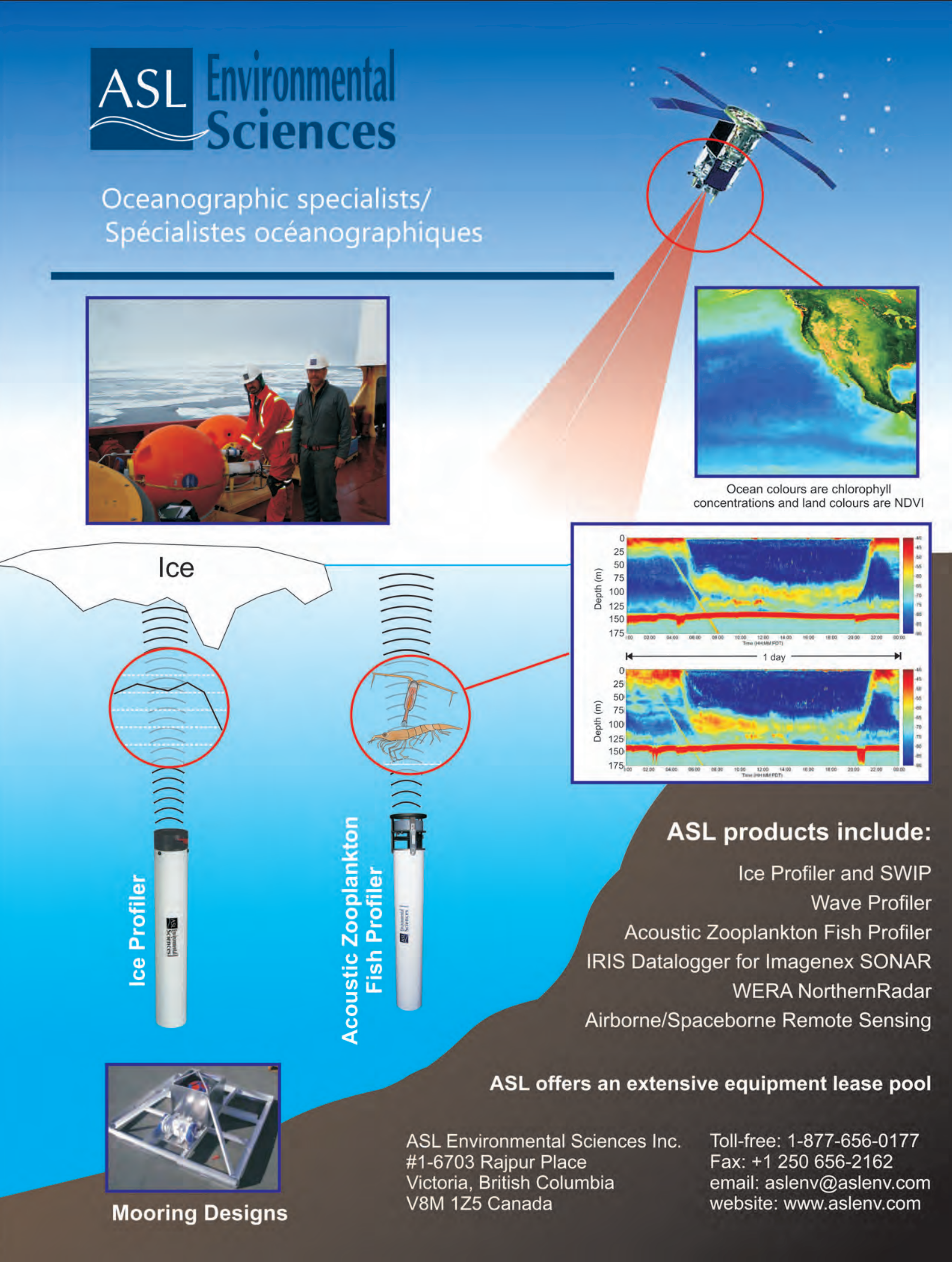
CELEBRATING 50 YEARS!

CÉLÉBRONS NOTRE 50e ANNIVERSAIRE!



1964 Patterson Medal presentation to distinguished scientists

Présentation de la médaille Patterson 1964 à d'éminents scientifiques


ASL Environmental Sciences
Oceanographic specialists/
Spécialistes océanographiques
Ocean colours are chlorophyll concentrations and land colours are NDVI
Ice
Depth (m)
1 day
Ice Profiler
Acoustic Zooplankton Fish Profiler
Mooring Designs
ASL products include:
Ice Profiler and SWIP
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## .... Words from the President

Friends and Colleagues:

Martha Anderson
CMOS President
Présidente de la SCMO

Detailed planning for our 50th congress in Fredericton is underway and we are very excited about the program. The joint congress with Canadian Geophysical Union (CGU) has the theme of *Monitoring of and Adapting to Extreme Events and Long-Term Variations*. One notable plenary speaker will be David Grimes, Assistant Deputy Minister, Meteorological Service of Canada and President, World Meteorological Organization. We look forward to hearing about his vision of the future of global weather services in this era of exponential increases in data and operational modelling capabilities.

As part of our 50th congress, the CMOS executive is taking this opportunity to seek views of our members and supporters regarding our congress traditions, and whether minor adjustments or major changes are needed to remain relevant and useful. More information on this session at congress can be found later in this bulletin.

We should all be proud of what CMOS has accomplished in the past 50 years, as we prepare to celebrate our Golden Jubilee. The addition of oceanographic disciplines 40 years ago has proven to have had great foresight and has strengthened the original 1967 Canadian Meteorological Society (CMS). This set the stage for scientific interactions that are becoming more important today as we move towards comprehensive environmental models and full-spectrum understanding of interactions in the physical environment.

We should be especially proud of our history with the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS), a government funding initiative aimed at universities that was proposed by CMOS and funded by Environment Canada. CFCAS became an independent granting agency but with many CMOS members serving on its board of directors.

[Continued on page 39]

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**Inside / En Bref**



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## *CMOS Bulletin SCMO*

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

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**Cover page**: For CMOS, 2017 will be the pivotal year of its 50th anniversary. An organizing committee led by our president, Martha Anderson, is already at work. **Pages 40** and **60**, for example, show the logo that we will use all year to mark the jubilee. But before we begin the celebration, the *CMOS Bulletin SCMO* editorial committee wanted its readership to remember our predecessors, those pioneers without whom we would not be celebrating our anniversary. The cover page shows two eminent scientists who received the 1964 Patterson Medal, a symbol of outstanding work in meteorology in Canada: Dr. Andrew Thomson, from Toronto (left), and Dr. Patrick D. McTaggart-Cowan, from Vancouver (centre). Mr. J.R.H. Noble (right), then director of the Meteorological Service of Canada, presents the prize to the winner. Mr. Noble received the Patterson Medal in 1976. It was a unique occasion in that the two laureates went on to become themselves directors of the Meteorological Service of Canada. Also of note, this photo was the first one published in *"Atmosphere"* 9th Issue, November 1965, page 3.

Voir la traduction française en page 40.


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## .... Words from the President [Continued / Suite]

CFCAS supported much important research in Canada with a total of $117 million allocated to projects from 2000 to 2012. The successor of CFCAS after funding wound down is the Canadian Climate Forum (CCF). I encourage our members to support the CCF in their important mission to disseminate and apply evidence-based climate knowledge to advance decision making for a safer and more sustainable Canada. See www.climateforum.ca

I hope you all share in the pride we feel for CMOS. This 50th anniversary is an opportunity for CMOS to really shine, to step up and have new visibility in the scientific community and in the public eye, and to provide new opportunities to strengthen our multi-displinary and cross-domain scientific interactions. This will not happen without new volunteers or new funds. Without new enthusiastic volunteers, fees will need to rise or donations will be needed to simply maintain our status quo level of service with paid staff. For our anniversary year, it is time to stretch beyond our comfortable status quo! Please contact your local or national executive to get involved, if you share our pride and want to be more than just a passive member of CMOS. We welcome your new ideas and enthusiasm. Our 50th anniversary is an opportunity to celebrate and to grow, so be part of the team!

I hope to see many of you in Fredericton in late May, where our year of celebrations will begin.

*Martha Anderson, CMOS President*

## .... Allocution de la présidente

Chers amis et collègues,

Nous sommes en train de planifier les détails de notre 50e congrès à Fredericton et nous sommes très fiers de notre programme. Le congrès, organisé conjointement avec l'Union géophysique canadienne (UGC), s'intitule *Adaptation aux événements extrêmes et aux variations à long terme et leur surveillance*. Nous avons recruté entre autres conférenciers notables, David Grimes, sous-ministre adjoint du Service météorologique du Canada et président de l'Organisation météorologique mondiale. Nous avons hâte de connaître son point de vue sur l'avenir des services météorologiques mondiaux, en cette ère d'augmentation exponentielle des données et des capacités de modélisation opérationnelle.

L'exécutif de la SCMO profite du 50e congrès pour sonder les membres et nos supporteurs sur les traditions liées aux congrès. Nous nous demandons si des ajustements mineurs ou des changements majeurs s'avèrent nécessaires pour rester pertinents et utiles. Vous trouverez d'autres informations sur cette séance du congrès dans ce bulletin.

Nous devrions tous nous sentir fiers de ce qu'a accompli la SCMO ces 50 dernières années, tandis que nous nous préparons à célébrer notre jubilé. L'ajout du volet océanographie, il y a 40 ans, s'est avéré une idée visionnaire, qui a renforcé l'organisation originale de 1967, la Société canadienne de météorologie (SCM). Ce regroupement a permis des interactions scientifiques qui se révèlent de plus en plus importantes aujourd'hui, tandis que nous nous dirigeons vers un modèle environnemental intégral et des connaissances qui couvrent le spectre complet des interactions de l'environnement physique.

Nous devrions être tout particulièrement fiers de notre histoire commune avec la Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA), une initiative de soutien gouvernemental, qui visait les universités et que la SCMO a proposée. Ses subventions provenaient d'Environnement Canada. La FCSCA est devenue par la suite une organisation de financement indépendante, mais plusieurs membres de la SCMO ont continué de siéger à son conseil d'administration. Elle soutenait de très importantes recherches au Canada. De 2000 à 2012, elle a octroyé 117 millions de dollars pour financer divers projets. Le Forum canadien du climat (FCC) a succédé à la FCSCA, après l'épuisement du financement. J'encourage nos membres à soutenir le FCC et son importante mission : disséminer et appliquer des connaissances climatologiques fondées sur des preuves, dans le but de permettre des décisions menant à un Canada sûr et durable. Consultez www.climateforum.ca

J'espère que vous ressentez tous cette fierté envers notre organisation. Notre 50e anniversaire présente une occasion pour la SCMO de vraiment briller, de prendre sa place, et de se donner une nouvelle visibilité au sein de la communauté scientifique et auprès du public. Nous devons également trouver des occasions de renforcer nos interactions multidisciplinaires et d'un domaine scientifique à un autre. Cette croissance ne sera possible qu'avec de nouveaux volontaires et un financement accru. Sans bénévoles enthousiastes, les frais d'adhésion ou les dons devront augmenter, et ce, simplement pour maintenir le niveau de service actuel du personnel rémunéré. Pour notre anniversaire, il est grand temps d'aller au-delà de notre zone de confort. Veuillez communiquer avec votre exécutif local ou national pour offrir vos services, si vous partagez notre fierté et souhaitez être un membre véritablement actif de la SCMO. Nous attendons vos idées et votre enthousiasme. Notre 50e anniversaire est l'occasion de célébrer et de croître. Soyez donc des nôtres!

J'espère vous voir en très grand nombre à Fredericton, à la fin de mai, où nous lancerons le programme des festivités pour l'année.

*Martha Anderson, Présidente de la SCMO*

# CELEBRATING 50 YEARS!

To honour the upcoming 50th anniversary of the creation of our Canadian society, this special version of our logo with the "50" added will be seen in use in the coming year. This logo represents our special recognition of all that CMS/CMOS has accomplished over this half century! As a community we have developed many proud traditions – publications, congresses, local events, and more. Let's use this logo to remind ouselves that we should use our Golden Jubilee year to work together and grow stronger in our shared goal of advancing meteorology and oceanography in Canada.

Volunteers are sought to assist with anniversary activities such as articles or publications, events, special speakers, fundraising for special scholarships or awards, and more. Please step up and join us at this exciting time! Contact president@cmos.ca if you would like to get involved.

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**Page couverture:** En 2017, la SCMO vivra une année charnière : celle de son 50e anniversaire. Un comité organisateur sous la direction de la présidente, Martha Anderson, est déjà à l'œuvre. Vous trouverez, par exemple, en **pages 40** et **60** le logo que nous utiliserons tout au long de cette année jubilaire. Mais avant de commencer les célébrations, le comité de rédaction du *CMOS Bulletin SCMO* a cru bon de rappeler à ses lecteurs nos prédécesseurs, ces pionniers sans qui notre anniversaire n'aurait pas lieu. Nous illustrons en page couverture deux éminents scientifiques qui ont reçu la médaille Patterson 1964, symbole d'un travail exceptionnel en météorologie au Canada : Andrew Thomson, Ph. D., de Toronto (à gauche), et Patrick D. McTaggart-Cowan, Ph. D., de Vancouver (au centre). Le prix fut remis par le directeur du Service météorologique de l'époque, M. J. R. H. Noble (à droite), récipiendaire de la médaille Patterson en 1976. L'occasion était unique en ce que les deux récipiendaires ont été eux-mêmes directeurs du Service météorologique du Canada. Fait à souligner également, ce fut la première photo publiée dans « *Atmosphere* » 9e numéro, Novembre 1965, page 3.

**Note: Thanks are due to Richard Asselin and Robert Jones for providing an improved version of this photograph.**

**Remerciements à Richard Asselin et Robert Jones pour avoir présenté une version améliorée de cette photo.**

# CÉLÉBRONS NOTRE 50e ANNIVERSAIRE!

Pour marquer le 50e anniversaire de la création de notre société, nous utiliserons cette version spéciale du logo, qui affichera le nombre « 50 ». Ce logo nous permet de reconnaître tout ce qu'a accompli la SCM/SCMO au cours de ce demi-siècle! En tant que communauté, nous avons mis sur pied plusieurs traditions dont nous sommes fiers : les diverses publications, les congrès, les événements locaux et plus encore. Utilisons ce logo pour nous rappeler de profiter de l'année de notre jubilé pour travailler ensemble et renforcer notre but commun : l'avancement de la météorologie et de l'océanographie au Canada.

Nous cherchons des bénévoles pour nous aider à organiser des activités liées aux célébrations : articles ou publications, événements, conférenciers spéciaux, campagne de financement pour des bourses spéciales ou des prix, et autres. N'hésitez pas à donner de votre temps en cette année de célébrations! Envoyez un courriel à l'adresse president@cmos.ca, si vous avez votre société à cœur.

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## ARTICLES

# The Canadian Arctic GEOTRACES Program: Biogeochemical and Tracer Study of a Rapidly Changing Arctic Ocean

by Roger François[1]

The Arctic marine system is undergoing rapid change as a result of climate-driven alterations in sea-ice cover and surface ocean circulation, which in turn can strongly influence biological productivity, air-sea exchange of climate-active gases, and the distribution of contaminants. Against this background of climate-driven changes, we expect significant expansions of commercial fishing, shipping, and exploitation of fossil fuel and mineral resources. Our present ability to fully evaluate the impacts of these changes and predict their future trajectory is limited by a poor understanding of the interacting chemical, physical, and biological processes that shape the functional characteristics and resiliency of Arctic marine ecosystems. To bridge this critical gap in knowledge, the Canadian Arctic GEOTRACES program, involving twenty-seven co-principal investigators from elevn Canadian universities and three government laboratories has completed two back-to-back research cruises in summer 2015 onboard the *CCG Amundsen* to examine the distribution and modification of geochemical tracers on a transect starting from the southern Labrador Sea and ending in the western Beaufort Sea **(Fig. 1).** International collaboration is at the core of the GEOTRACES program, and the 2015 Arctic GEOTRACES program was built on the coordination of field work between three nations (US, Germany, Canada) to produce a quasi-synoptic database over the entire Arctic Ocean. The Canadian transect links the North Atlantic, which was visited in 2014 by the French GEOVIDE program, to the US GEOTRACES Arctic transect, which entered the western Beaufort Sea from the North Pacific. The German GEOTRACES transect started from Fram Strait and overlapped with the US transect at the North Pole. An important goal of the Canadian section is documenting the transformation of Pacific water as it transits through the Canadian Arctic Archipelago (CAA) towards the North Atlantic.

***2015 CCGS Amundsen expedition LEG 2***
***GEOTRACES/ARCTICNET***
**July 10 – August 20, 2015**
**Quebec City – Kugluktuk**

The first leg was shared between the Canadian Arctic GEOTRACES project and ArcticNet. As part of the international GEOTRACES program, the principal mandate of our project was to study the input, removal and cycling of trace elements and isotopes in the water column, and to use this information to document, monitor, and predict the evolution of physical and biogeochemical processes in the Arctic Ocean. Our project was also complemented by very extensive biological and trace gas measurements, which not only met the broader requirements of NSERC's CCAR (Natural Sciences and Engineering Research Council, Climate Change and Atmospheric Research) program but were also of direct relevance to the long-term goals of ArcticNet, facilitating coordination of sampling between the two programs.

Sampling operations for GEOTRACES during this leg consisted of seawater sampling with ArcticNet's 24 x 12 L rosette – CTD (Niskin-type bottles) and GEOTRACES' 12 x 12 L rosette – CTD (Go-Flo bottles) to sample seawater under trace metal clean conditions, marine particle sampling with 6 McLane large volume in-situ pumps, aerosol sampling with a volumetric flow controlled high volume sampler, and underway trace gas analysis with a Membrane Inlet Mass Spectrometer (MIMS) and a Gas Chromatograph (GC). Additional GEOTRACES activities included incubations for productivity measurements with different isotopic tracers ($^{13}C$, $^{15}N$, $^{32}Si$, $^{18}O$, 2h $^{14}C$ and FRRF [Fast Repetition Rate Fluorometry]) complementing incubations conducted by ArcticNet (24-h $^{14}C$ incubations) and productivity estimates from water column measurements ($O_2$/Ar, triple O isotopes, $^{234}Th$ deficit). In addition, ship-board manipulation experiments were also conducted to examine the impacts of ocean acidification and enhanced mixed layer stratification on phytoplankton productivity and physiological ecology, and fifteen rivers were sampled to assess continental input into the Canadian Arctic Archipelago.

The initial GEOTRACES plan for this leg was to occupy two stations in the Labrador Sea, four in Baffin Bay, and nine in the Canadian Arctic Archipelago. Additional stations were to be occupied for ArcticNet on a section between Greenland and Devon Island, and in Kane Basin, Kennedy Channel, and Petermann Fjord. Time was also allocated for additional stations in Queen Maud Gulf as part of the W. Garfield Weston Foundation - Parks Canada - ArcticNet collaborative project.

[1] University of British Columbia, Vancouver, BC

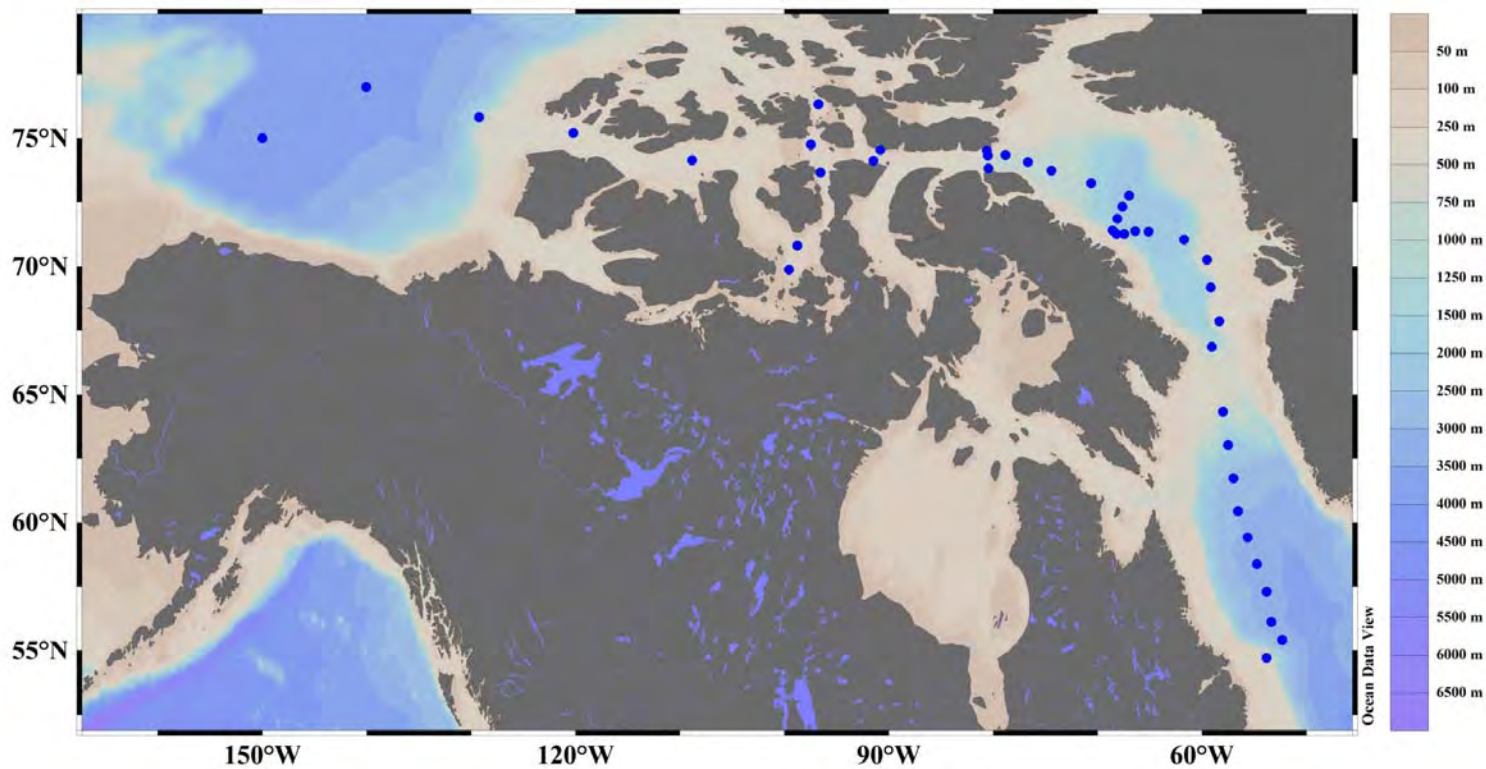


Figure 1: Section of GEOTRACES stations occupied between July 10 and October 1, 2015. Red circles indicate full hydrographic stations; blue circles indicate supplementary XCTD.

The work in the Labrador Sea was completed on schedule. However, as we were crossing Davies Strait, things went suddenly (and literally) south, as the ship was unexpectedly diverted to Hudson Bay for ice-breaking duties! The resulting two-week (!) hiatus (from July 19th to August 3rd) demanded a dramatic re-organization of the cruise plan. To the benefit of the GEOTRACES program, ArcticNet cancelled nearly all its stations and the remaining science plan was reduced to occupying three of the four GEOTRACES Baffin Bay stations and seven of the nine archipelago (CAA) stations (**Fig. 2**). GEOTRACES sampling strategy in the CAA was also adjusted to existing ice conditions and to optimize scientific return within the remaining time. By the end of this leg, GEOTRACES only lost one station in Baffin Bay and two in the CAA, but the latter two could be recovered during the following leg. We managed to complete 67 hydrocasts with ArcticNet's CTD-rosette, 31 hydrocasts with GEOTRACES' trace metal clean CTD- rosette, and 24 casts with GEOTRACES' six large volume pumps, resulting in 1,545 seawater and marine particle samples for multi-element and isotopic analysis (**Table 1**). We also conducted 278 incubations for carbon fixation and nutrient uptake measurements (88 two-hour $^{14}C$ incubations/FRRF, 60 $^{13}C$ and $^{15}N$ incubations, 60 $^{32}Si$ incubations, 60 $^{18}O$ incubations, 10 $^{55}Fe$ incubations), which were complemented by ArcticNet's 156 twelve-hour $^{14}C$ incubations. Finally, two $CO_2$ / light manipulation experiments and sampling at 15 Arctic rivers draining in the CAA were also successfully completed.

***2015 CCGS Amundsen Expedition LEG 3b***
***GEOTRACES/ARCTICNET***
**September 4 – October 1, 2015**
**Sachs Harbour – Resolute**

Note from the Editor: An overview of this work and other elements of the international collaboration were published in the February 2016 *CMOS Bulletin SCMO*, "Canadian Arctic Programme, Cruise Report", by Roger François and Philippe Tortell, Vol.44, No.1, page 27.

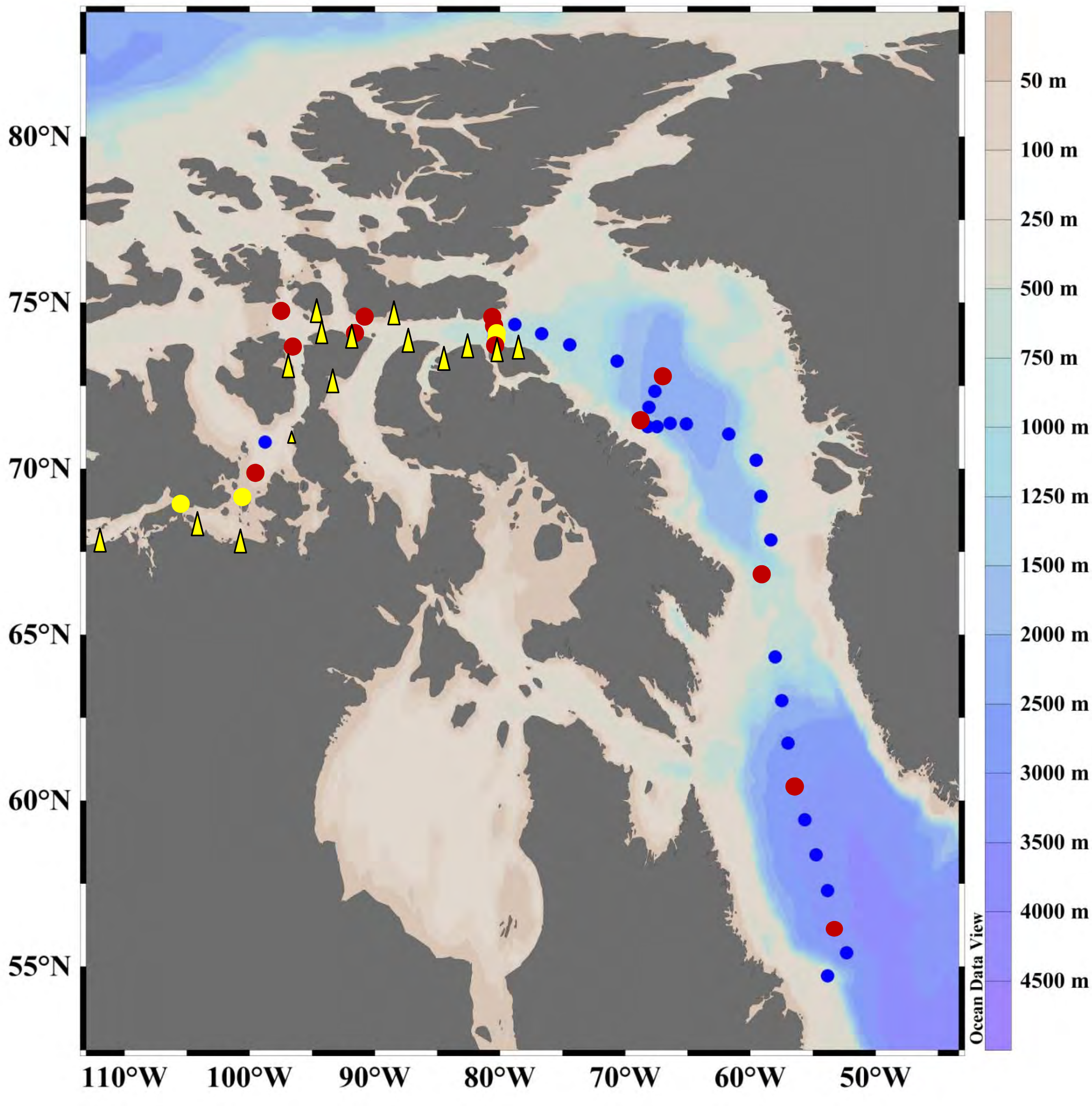


Figure 2: Sampling stations during the first leg. Red and blue circles are as for Fig. 1. Yellow triangles indicate the location of the sampled rivers. Yellow circles are ArcticNet stations.

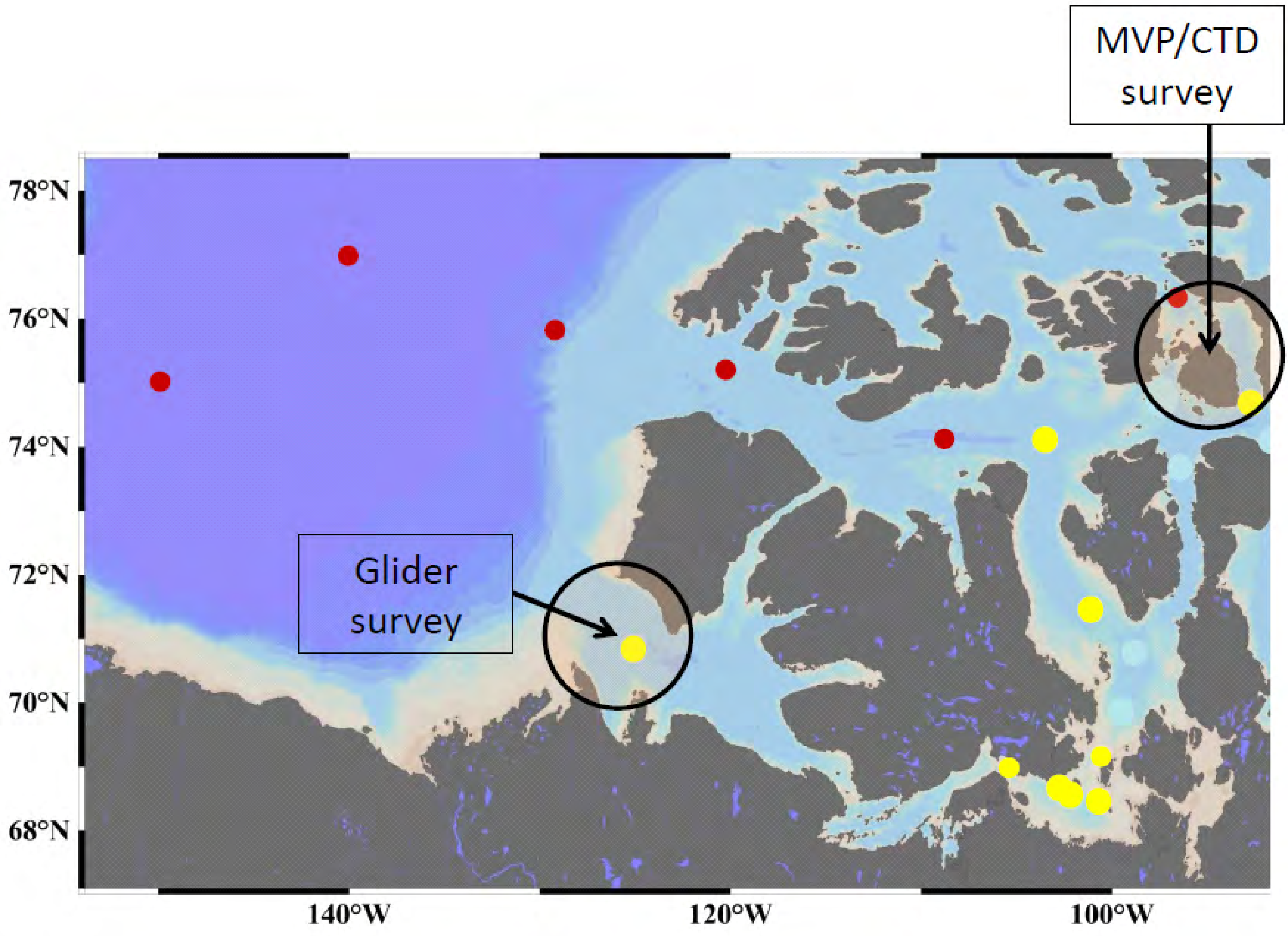


Figure 3: Sampling stations during the second leg. Red circles indicate GEOTRACES stations and yellow circles are ArcticNet stations. The two black circles show the location of the (Moving Vessel Profiler) MVP/CTD survey and glider deployment.

The second leg was also shared between the Canadian Arctic GEOTRACES project and ArcticNet and was comparatively uneventful but for the visit of three swimming polar bears showing undue interest to the Kevlar line supporting our trace metal rosette (https://www.youtube.com/watch?v=JC2befsNa1Y). As during our first leg, the main GEOTRACES sampling operations consisted of seawater sampling with ArcticNet's rosette, GEOTRACES' trace metal clean rosette, and particle sampling with large volume in-situ pumps. The biogeochemical study conducted during this leg (**Table 2**) was complemented by a four-day process study during which a Moving Vessel Profiler was deployed to study mixing in Wellington, Maury, and Perry Channels. The goal of this work is to assess the impact of physical processes on the supply of micronutrients to surface waters. Toward the same goal, a glider was deployed in Canada Basin during the preceding Leg 3a (August 21 – September 3). The glider data provided high resolution observations of water column hydrography and micro-structure that will provide new insight into mixing and turbulence across the Arctic continental shelf.

Overall, the Canadian Arctic GEOTRACES summer field program was a resounding success, notwithstanding the unexpected change in ship-operations during the first leg that resulted from our two-week diversion for ice-breaking duties. It must be noted, however, that this excursion to Hudson Bay had a large negative impact on the work plan of our colleagues from ArcticNet, and we are extremely grateful for their willingness to reduce their program to ensure that our field campaign was successful. If anything, the situation we faced this summer further points out the blatant inadequacies for ship time funding, allocation, and availability for oceanographic research in this country. Canada claims to be a country where excellence in oceanographic research is conducted. Indeed, Canadian oceanographers continue to make important contributions to remain at the forefront of their field. However, their efforts are continuously hampered by the lack of a dedicated fleet for ocean research and the lack of sensible mechanisms for the allocation of ship time needed to conduct large scale operations. While improving the infrastructure takes time, even when there is a will, organizational changes to better coordinate ocean research funding and platform availability could and should be undertaken as soon as possible by our funding agencies.

The ocean science community must start a coordinated effort to send a clear message that the existing funding mechanisms for ship time allocation are inadequate to meet the needs of ocean research, and a new approach needs to be developed with consultations between NSERC, DFO, CCG (Department of Fisheries and Oceans, Canadian Coast Guard), and Canadian oceanographers.

| | |
|---|---|
| **Hydrography/CTD sensors** | **Trace gases** |
| Pressure | Biogenic gases |
| Temperature | $CH_4$, $N_2O$ |
| Salinity | $O_2/Ar$, $N_2/Ar$ (K1; LS2; BB1, 2, 3; CAA1, 3, 4, 5, 6, 7) |
| Oxygen | Triple oxygen isotopes (K1; LS2; BB1, 2, 3; CAA1, 3, 4, 5, 6, 7) |
| Fluorescence | Noble gases (K1 and BB2) |
| Light transmission | **Trace elements and isotopes** |
| **Nutrients** | Dissolved and particulate trace metals |
| Phosphate | Al, Mn, Fe, Cd, Zn, Cu, Pb, Ga, Ba, REE, Hg, MeHg |
| Nitrate/Nitrite | Dissolved and particulate radioisotopes |
| Ammonia | $^{230}Th$, $^{231}Pa$, $^{234}Th$, $^{228}Ra$, $^{224}Ra$, $^{223}Ra$ |
| Silicate | Dissolved and particulate radiogenic isotopes |
| **Chemical parameters** | Nd, Pb |
| Dissolved inorganic carbon | Dissolved and particulate stable isotopes |
| Total alkalinity | $\delta^{18}O$ in water |
| pH | $\delta^{13}C$ in DIC |
| Dissolved organic carbon | $\delta^{15}N$ and $\delta^{18}O$ in nitrate |
| Fluorescent dissolved organic matter | $\delta^{30}Si$ |
| Coloured dissolved organic matter | $\delta^{53}Cr$ |
| Thiols | $\delta^{56}Fe$ |
| Organic ligands | Anthropogenic isotopes |
| **Biological parameters** | $^{129}I$, $^{236}U$, $^{135}Cs$ |
| Particulate organic carbon | **Large volume in-situ pumps** |
| Particulate organic nitrogen | Paticulate $^{230}Th$, $^{231}Pa$, $^{234}Th$ |
| Size fractionated chlorophyll a | Paticulate Si, Nd and Cr isotopes |
| Pigments | |
| Particulate biogenic silica | |
| Flow cytometry | |
| Genomics | |
| Proteomics | |
| Incubations | |
| $^{14}C$ uptake (K1; LS2; BB1, 2, 3; CAA1, 2, 3, 4, 5, 6, 7; VS) | |
| $^{13}C$ uptake (K1; LS2; BB1, 2, 3; CAA1, 3, 5, 6, 7) | |
| $^{15}NO_3$ uptake (K1; LS2; BB1, 2, 3; CAA1, 3, 5, 6, 7) | |
| $^{15}NH_4$ uptake (LS2; BB1, 2, 3; CAA1, 3, 5, 6, 7) | |
| $^{32}Si$ uptake (LS2; BB1, 2, 3; CAA1, 3, 5, 6, 7) | |
| $H_2{}^{18}O$ uptake (K1; LS2; BB1, 2, 3; CAA1, 3, 5, 6, 7) | |
| $^{55}Fe$ uptake (CAA3, 7) | |

Table 1: List of parameters measured or sampled during the first leg

| | |
|---|---|
| **Hydrography/CTD sensors** | **Trace elements and isotopes** |
| Pressure | Dissolved and particulate trace metals |
| Temperature | Al, Mn, Fe, Cd, Zn, Cu, Pb, Ga, Ba, REE, Hg, MeHg |
| Salinity | Dissolved and particulate radioisotopes |
| Oxygen | $^{230}$Th, $^{231}$Pa, $^{234}$Th, $^{228}$Ra, $^{224}$Ra, $^{223}$Ra |
| Fluorescence | Dissolved and particulate radiogenic isotopes |
| Light transmission | Nd, Pb |
| **Nutrients** | Dissolved and particulate stable isotopes |
| Phosphate | $\delta^{18}$O in water |
| Nitrate/Nitrite | $\delta^{13C}$ in DIC |
| Silicate | $\delta^{15}$N - nitrate |
| **Chemical parameters** | $\delta^{30}$Si |
| Dissolved inorganic carbon | $\delta^{53}$Cr |
| Total alkalinity | $\delta^{56}$Fe |
| pH | Anthropogenic isotopes |
| Dissolved organic carbon | $^{129}$I, $^{236}$U, $^{135}$Cs |
| Fluorescent dissolved organic matter | **Large volume in-situ pumps** |
| Coloured dissolved organic matter | Paticulate $^{230}$Th, $^{231}$Pa |
| Thiols | Paticulate Si, Nd and Cr isotopes |
| Organic ligands | |
| **Biological parameters** | |
| Particulate organic carbon | |
| Particulate organic nitrogen | |
| Pigments | |
| Particulate biogenic silica | |
| Genomics | |
| Proteomics | |

Table 2: List of parameters measured or sampled during the second leg

Note: First published in "*Ocean Science Newsletter*", Number 86, January 2016. Reproduced here with the authorization of the Editor.

# Summer 2015 over the Canadian Prairies, early drought followed by good rains: yields and quality were close to normal with high spring wheat protein content

by Ray Garnett[1] and Madhav Khandekar[2]

Abstract: We provide a brief overview of 2015 summer's weather over the Canadian Prairies where most of Canada's grain is produced. We have analyzed how the early summer heat and dryness and wet fall affected the yield and quality of spring wheat and canola yields. This article also shows how the heat and dryness that reduced yields was forecast and addresses a cooling trend in growing season temperatures over the past 31 years.

## Introduction

The Canadian prairie provinces of Alberta, Saskatchewan, and Manitoba produce an average of over 50 mln tonnes of grain a year. Severe droughts can affect prairie agriculture as well as the national economy. Wheaton (2011) describes how the droughts of 2001 and 2002 affected Canada's Gross National Product (GNP), which fell $5.8 billion during 2001 and 2002, with the biggest loss occurring in 2002 at $3.6 billion.

The 2015 growing season of May-July over the Canadian Prairies was the second driest for the period 1999-2015 averaging 49 mm per month in contrast to the wettest growing seasons of 2005 and 2010 when precipitation averaged 88 mm/month. May-June of 2015 was the fourth driest for the period 1950-2009 when the eastern prairies were excluded.

The agricultural drought (less than 50% of normal rainfall) during May and June reduced spring wheat and canola yields to 2.8 and 1.8 t/ha. (Statistics Canada, October 2015). This was 7% below trend for both crops for the period 1985-2014. In December Statistics Canada revised preliminary yield estimates for spring wheat and canola upwards to 2.90 and 2.10 (3% below and 8% above trend). The reduced yield estimates can be attributed to Peace River (PR), Palliser North (PN) and Palliser Brown (PB) zones experiencing 38% of normal rainfall during May and June combined with June-July temperatures that were 1.4°C above normal. Over the Eastern Prairies (EP) May-June rainfall was 108% of normal with June-July temperatures slightly above normal. The location of these zones is shown in Figure 1.

Table 1 shows that May and June rainfall in the Peace River, Palliser North, and Palliser Brown zones averaged 38% of normal during spring wheat's important tillering and stem extension growth phases. Problems with grasshopper infestation were reported in late June and persisted into early July (Ray Garnett Climate Letter July 8, 2015). Manitobans witnessed the smoky weather in June as a consequence of Saskatchewan's forest fires. The nine-week dry spell came to an end in mid-July when rains in excess of 200% of normal fell over most of the prairies. Preliminary December Statistics Canada's yield estimates imply that the July rains were sufficiently timely to largely offset earlier May-June dryness and June-July heat.

### July 2015 temperatures were forecast to the quintile in late February 2015

On February 26$^{th}$ 2015 grain producers were warned of July heat, "*At this time ACC, is forecasting July temperatures to be in the top quintile for the period 1951-2009 or 1.0 to 2.4ºC above normal (18.9-20.1ºC)*." What happened? July temperatures averaged 18.9 ºC, which was 1.2ºC above normal and in the top quintile for the period 1950-2009 (Ray Garnett Climate Letter, September 9, 2015).

A semi-permanent ridge, described as 'Rex blocking' by the Weather Channel persisted over the west coast for months on end. Around July 10$^{th}$ it shifted to the centre of the continent then collapsed shortly afterwards. The drivers behind this blocking pattern are considered to have been the PNA (Pacific North American) and PDO (Pacific Decadal Oscillation) drivers shown along the x-axis of Figure 2 from Garnett and Khandekar (2014). The predictors along the x-axis of Figure 2 are the PNA index in December, PDO index in January, the AP (Accumulated Predictors) index anomaly in March and April, Nino 3.4 sea surface anomaly in May, and PNA index in May. The

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[2] Markham, Ontario. Madhav Khandekar, is a climate consultant and (International Panel on Climate Change) IPCC expert reviewer (2007).

AP index is a proxy variable for solar activity. The PNA atmospheric flow pattern originally identified by Wallace and Gutzler (1981) is representative of a certain preferred configuration of the mid-troposphere


Figure 1: Agro-eco regions of the Canadian prairies (Padbury *et al*. 2002) reprinted with permission.

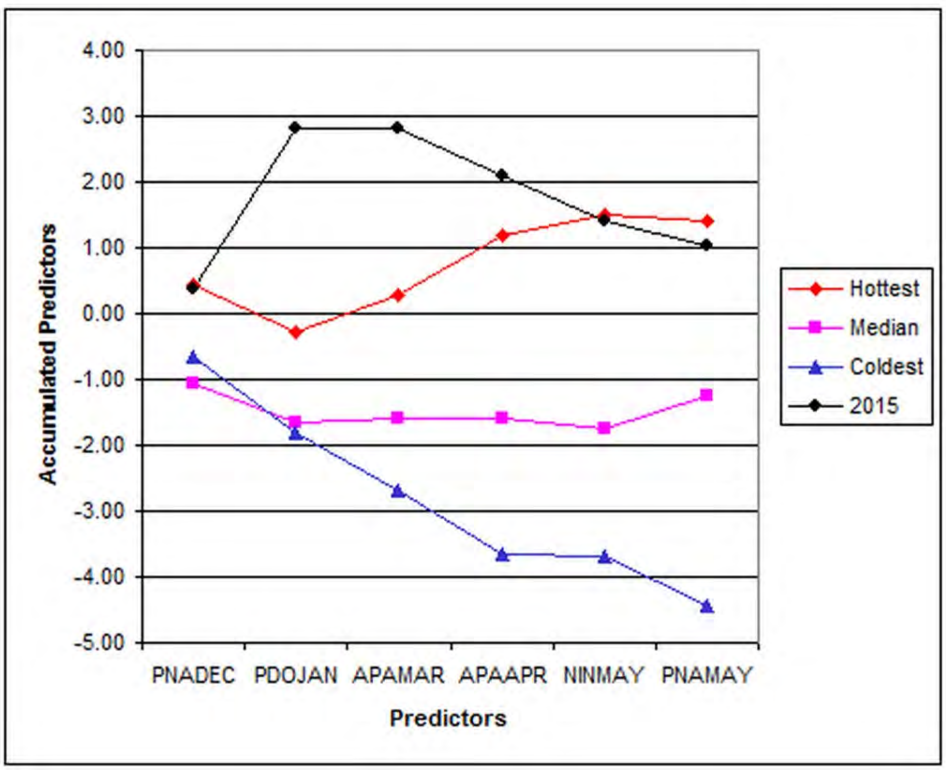


Figure 2: Composite of accumulated indices prior to the five hottest (1957, 1960, 1975, 1985, and 2002) five median (1954, 1965, 1982, 1985, and 1991), and five coldest (1971, 1972, 2005, 2008, and 2009) Prairie Julys.

geopotential height field in the longitudinal sector extending from the mid-Pacific to the south-eastern United States. The Pacific Decadal Oscillation (PDO) index is a long-lived El Niño-Southern Oscillation (ENSO)-like pattern of Pacific climate variability, whose climatic fingerprints are most visible in the North Pacific-North American sector with secondary signatures in the tropics. The predictor accumulation on the y-axis exceeded 1 S.D. or 2.79 flagging the risk of extreme July heat. In Saskatchewan hot Julys tend to be dry Julys (r. =-0.43) and July rainfall is an important determinant of spring wheat yield (r. = 0.47) such that July heat poses a risk to the spring wheat crop, Garnett (2002). July weather is the single most critical month affecting spring wheat yields, King (1987).

Table 1 reveals that May and June rainfall in the Peace River, Palliser North, and Palliser Brown zones averaged 38% of normal during spring wheat's important tillering and stem extension growth phases. Problems with grasshopper infestation were reported in late June and persisted into early July (Ray Garnett Climate Letter July 8, 2015). Manitobans witnessed the smoky weather in June as a consequence of Saskatchewan's forest fires. The nine-week dry spell came to an end in mid-July when rains in excess of 200% of normal fell over most of the Prairies. Preliminary December Statistics Canada's yield estimates imply that the July rains were sufficiently timely to largely offset earlier May-June dryness and June-July heat.

| **2015** | **MAY** | | **JUNE** | | **JULY** | |
|---|---|---|---|---|---|---|
| Region | Rainfall % of normal | Temperature DFN | Rainfall % of normal | Temperature DFN | Rainfall % of normal | Temperature DFN |
| Peace River **(PR)** | 48 | 0.7 | 55 | 2.1 | 74 | 2.1 |
| Palliser North **(PN)** | 26 | -0.7 | 47 | 1.4 | 111 | 1.0 |
| Palliser Brown **(PB)** | 16 | -0.9 | 35 | 1.4 | 107 | 0.4 |
| Eastern Prairies **(EP)** | 95 | -0.7 | 121 | -0.4 | 109 | 1.0 |
| Prairies as a whole | 54 | -0.4 | 57 | 0.9 | 108 | 1.2 |

Table 1. Climatic summary of the 2015 Canadian Prairie growing season by Agro Ecological zone based on 31 stations; normals 1980-2009. DFN represents departure from normal in degrees Celsius.

**The dry June-August was forecast in late March**

In late March grain producers were advised, "*That operational research points to June-August precipitation being in the bottom quintile averaging 45-56 mm." and that "A regression model using PDODec, MJOFeb, PNAJan, NPMay and APJan predictors forecasts average June-August rainfall of 53 mm (78% of normal)*". What happened? June-August rainfall averaged 58 mm. (Ray Garnett, Climate Letter, October 26, 2015). MJO stands for the Madden-Julian Oscillation and NP for North Pacific. These predictor types are further described in Garnett and Khandekar (2014).

**Why such a dry May-June in spite of El Niño?**

Garnett *et al,,* 1998, show that the sign of the PNA index is positive during months with strong ridging at the 700 millibars level over western Canada with reference to 12 months of the year. During a positive phase of the PDO, waters in the north central Pacific Ocean cool and waters along the west coast of North America warm, altering the path of the jet stream, augmenting the effect a positive PNA pattern. Garnett and Khandekar (2014) show that a positive PDO in the winter and spring months is conducive to warmer and drier than normal weather during the summer months.

Leading up to the summer of 2015 the PNA index value in December was 0.37 while the PDO index between December and March was strongly positive with values ranging from 2.00 to 2.51. As part of the annual cycle, the northern hemisphere circumpolar vortex contracts in size as the summer approaches and a deep trough at the 500 mb level typically forms on the west coast near the summer solstice bringing the heaviest rains of the year to the Prairies. The Weather Channel during June revealed zonal flow or ridging of the jet stream along the west coast rather than the usual troughing largely explaining the very dry June.

| | Mean protein content in % | 1 CWRS | 2 CWRS | 3 CWRS | Canada Feed |
|---|---|---|---|---|---|
| 1954-1995 mean | 135 | 39 | 27 | 24 | 10 |
| 2015 | 141 | 40 | 34 | 17 | 9 |

Table 2: Canadian Grain Commission (CGC) estimate of quality for the 2015 Canada Western Red Spring (CWRS) crop compared to average.

| **2015** | **MAY** | | **JUNE** | | **JULY** | |
|---|---|---|---|---|---|---|
| Region | Rainfall % of normal | Temperature DFN | Rainfall % of normal | Temperature DFN | Rainfall % of normal | Temperature DFN |
| Peace River **(PR)** | 59 | 0.5 | 60 | 1.5 | 109 | 1.2 |
| Palliser North **(PN)** | 111 | 0.5 | 157 | 0.7 | 184 | 2.5 |
| Palliser Brown **(PB)** | 100 | 0.6 | 120 | 0.5 | 188 | 2.4 |
| Eastern Prairies **(EP)** | 78 | 0.5 | 98 | 2.1 | 98 | 2.8 |
| Prairies as a whole | 91 | 0.7 | 121 | 1.6 | 119 | 2.5 |

Table 3. Climatic conditions during the harvest period of August to October

It is hypothesized that PNA-PDO induced blocking overpowered the annual cycle and natural troughing tendency. Moreover, the PNA-PDO induced blocking prevented moisture-laden air from traversing the Rocky Mountains that typically happens during El Niño conditions as described by Garnett (2002). The Pacific Ocean is the primary moisture source for the western prairies. In addition, stratospheric winds or the Quasi-Biennial Oscillation (QBO) winds were easterly and unfavourable for May-July rains. The mechanism is described by Garnett *et al.*, 2006.

**Quality of the 2015 red spring wheat crop**

Table 2 shows that the quality of the hard red spring wheat crop was very close to average for the top two grades. The protein content was very high as a result of the drier and warmer than normal June-July. An inverse relationship exists between yield and protein content for bread wheat classes with generally a 0.5% increase in protein content for each 5% reduction in yield as discussed by Garnett (2002).

A Canadian Grain Commission spokesman described "*harvest progress as normal and that early harvested spring wheat graded well while later harvested wheat was downgraded to the 2 CW class as a consequence of mildew and sprouting*". At September 14th 46% of spring wheat in Saskatchewan was harvested. (Ray Garnett Climate Letter September 23, 2015). Table 2 shows that the amount of spring wheat that graded 2 CW was higher than the average, probably the consequence of heavy precipitation in the Palliser North and Palliser Brown zones during September and October evident in Table 3. By October 12, 90% of spring wheat was harvested (Ray Garnett Climate Letter, October 26, 2015). The normal harvest period for spring wheat is mid-August to mid- October.

**Is the Prairies growing season becoming shorter?**

Besides being the source of life on planet earth, the sun also influences our weather and climate. Figure 4 shows a 1.5 ºC cooling in May-July temperatures over the Canadian prairies for the period 1985-2015. The number of stations behind the 1985-2010 May-July temperature trend is as follows: 400 stations for 1985-2007, 105 stations for 2008-2010, and 31 stations for 2011-2015. This temperature trend corresponds with decreasing AP or geomagnetic activity shown in Figure 5.

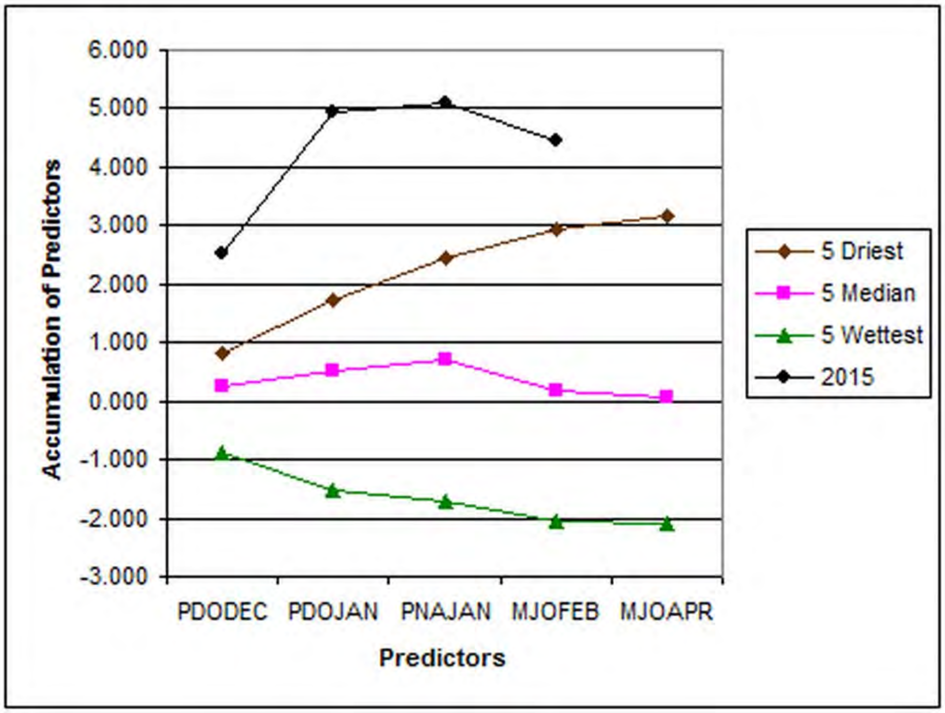


Figure 3: Composite of accumulated PNA, PDO, and MJO indices for the five driest (1979, 1984, 2001, 2003, and 2006), five median (1981, 1982, 1983,1986, and 1989), and five wettest (1991,1993, 2000, 2002, and 2005) June-August.

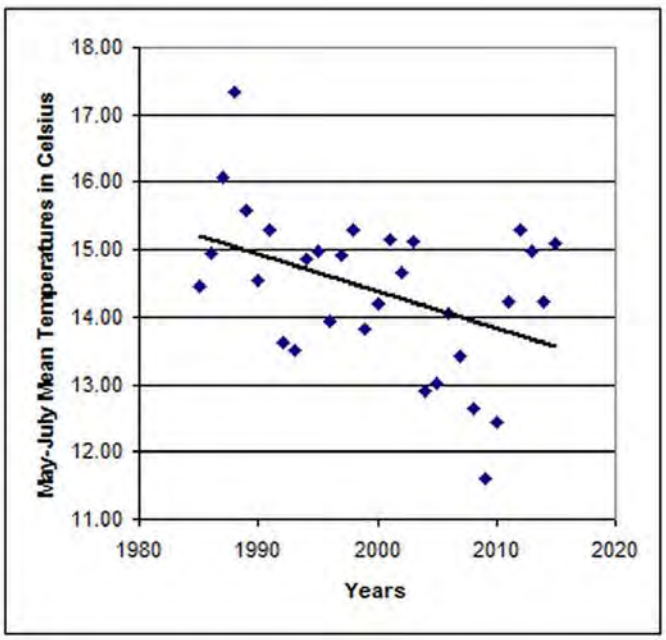


Figure 4: May-July temperatures

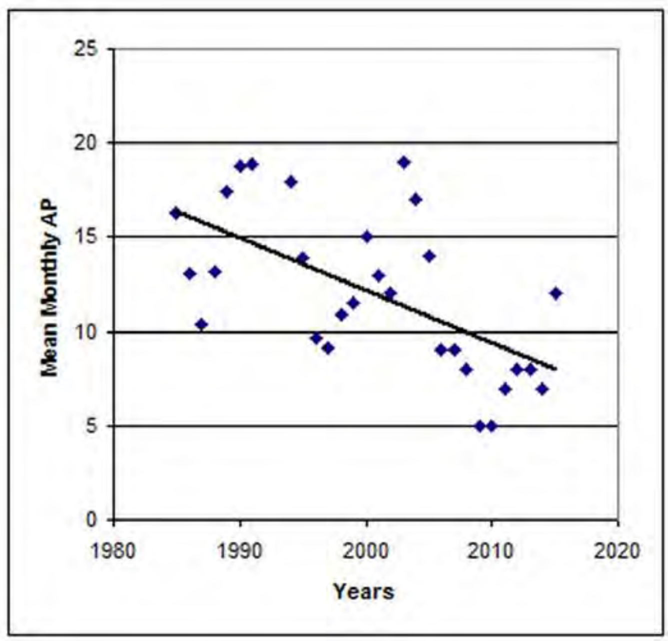


Figure 5: Mean monthly AP index

The AP index is defined as the earliest occurring maximum 24-hour value of a geomagnetic storm event obtained by computing an eight-point running average of successive three-hour AP indices. Over many years, the values of the AP index provide a maximum disturbance measure useful for identifying major geomagnetic storms chronologically and by amplitude from largest to smallest (Google Search on AP, NOAA, Geophysical Data Center). A study by Georgieva (2005) demonstrates that the AP index is more representative of solar activity than a monthly count of sunspots and hence can be used as a proxy variable for solar variability.

Landsheidt (2000), in using Maynards aa index of geomagnetic activity, found using repeated three-year smoothing, that global land and sea surface temperatures lagged the aa index by 4-8 years between 1868 and 1985. The correlation was r.=0.96. Maynards aa index, as with the more modern AP index, reflects the effects of energetic solar eruptions near earth. He used these findings to predict decreasing global temperatures between 2000 and 2010.

Figures 5 indicates that the mean monthly AP index fell 11 points (17-6) between 2000-2010 while Prairies May-July temperatures shown in Figure 4 cooled by 2.5º C. May-July 2009 was the coldest for the period 1985-2015 and coincided with an extremely low mean monthly AP value of 5. In 2010 the AP index was again extremely low and corresponded with the wettest summer in 60 years previously described by Garnett and Khandekar in 2010. May-July of 2010 was also the second coldest for the period 1985-2015. The mechanism by which the sun (and by proxy the AP index) affects weather is presented in Garnett *et al.*, (2006). The correlation between the mean monthly AP index (September to August) with Canadian Prairies May-July temperatures during 1985-2015 was 0.37 significant at the 5% level. The summers of 1992 and 1993 were treated as outliers in this analysis. Garnett and Khandekar (2014) point out that the June 15th 1991 Pinatubo Volcanic eruption reduced June-August temperatures to 2 ºC below normal.

Figure 6 reveals that there has been an average of 65 sunspots during September-December of 2015, which is the beginning of agricultural year 2016, and the beginning of year 7 of sunspot cycle #24 (counting intervals from year 1). Based on nine previous 11-year sunspot cycles, solar activity can be expected to decline through 2016 as well as through 2020. This suggests a continuing cooling trend of May-July Prairies temperatures. Archibald (2014) reports that cycles 24 and 25 have been named the Eddy Solar Minimum after the late John A. Eddy, an astronomer who worked at the U.S. National Center for Atmospheric Research (NCAR).

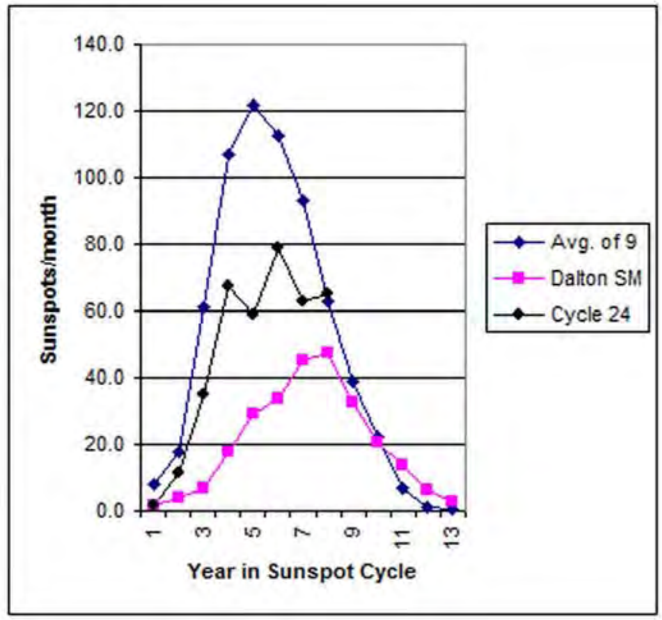


Figure 6: Mean monthly sunspots during nine 11-year sunspot cycles in the 20th century, the Dalton Minimum of 1798-1823, and cycle #24 that commenced in 2009. Data compiled by E.R. Garnett.

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## CMOS and Arctic Leader – Interview with Martha Anderson[3]

Interview carried out by Ann McMillan[4]

**1. Please tell me a bit about yourself? How did you get interested in meteorology? And oceanography?**

I grew up in Cornwall, Ontario, and was interested in science. My father was a navigator in the Second World War and talked about knowing the clouds and upper winds, plus meteorology was interesting and I found math relatively easy. In high school, we did the Jackson Vocational Interest Survey in which we answered about four hundred paired questions about our likes and dislikes and we received a printout summary of our career interests. Mine included physical and biological sciences, and trade skills. The physical sciences career list included meteorologist, and at age 15 I decided that this would be an interesting career.

When I attended Brock University on a program that allowed us to skip Grade 13, I decided to take biochemistry, but found there was too much tedious memorization. After one year, I transferred to McGill University to pursue my original idea of meteorology. At that time, McGill gave a course on "*Science in the Modern World*" which was inspirational for me … how science is used to solve problems for the real world. I can honestly say that I didn't write one essay at university, but all the math and physics we did in the meteorology program was straightforward.

When I left McGill I was hired by Environment Canada for Meteorologist Operational Course #6. I was posted to Halifax and worked at the METOC Centre at CFB Halifax, and the old public weather office in Bedford, and I also was Wing Meteorological Officer at 12 Wing Shearwater. My first exposure to the near-north was spending two weeks working in Goose Bay. I enjoyed the northern lights every morning at four AM, as I scraped off frost from my car window to go to work.

It was at the Halifax METOC Centre where I got interested in oceanography. Meteorologists took turns working the Ocean Desk and produced the sea surface temperature and ocean feature analysis charts. I was also privileged to take a three-week course on oceanography at Royal Roads in Victoria, which included a one-day cruise so I could learn to launch CTDs and use other equipment.

**2. You are in one of the few government management positions that have both MET and OC together….what advantages do you see in having these two fields closely aligned? (We note that Department of National Defence (DND) has combined these two science areas but they remain in different departments elsewhere in the federal government – DFO (Fisheries and Oceans Canada) and ECCC (Environment and Climate Change Canada).**

These two specialties within NATO countries are sliced and diced differently. Instead of linking meteorology and oceanography organizationally, some nations link oceanography and hydrography, while others link meteorology with geomatics. In the Canadian Armed Forces organization, all these specialities are under the CF Intelligence Command, because we are all providing a full spectrum of different kinds of information for situational awareness and decision making in the conduct of military operations. We focus on the impact of the physical environment on military capabilities. I believe that an integrated approach to the delivery of services gives a

[3] Director of Meteorology and Oceanography at Department of National Defence and CMOS President

[4] Editor, Arctic SIG and Chairperson, CMOS Ottawa Centre

stronger system, and in our case it makes fundamental scientific sense to connect the atmosphere and oceans. We rely heavily on ECCC and DFO for support in our Canadian Forces Weather and Oceanographic Service (CFWOS) program.

My background, with experience both at ECCC and DFO, led me to that belief. In 2003, I worked with Denis d'Amours and Doug Bancroft who were then working on developing Operational Oceanography at DFO headquarters in Ottawa. We also had a focus on funding for ocean science work related to climate change. It was very interesting, and at that time I could see that climate change was going to have a huge impact on Canada's Arctic.

Being the DND member of the steering committee for the Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS) Program between DFO/DND/ECCC has illustrated over and over again how departments working together can make resources go much further than a single department could. Outputs from prediction systems with integrated oceans are proving extremely important to Canada and government science as a whole, especially in the Arctic. This is an important project as it demonstrates Canada's leadership role in niche areas such as incorporation of sea ice into environmental models.

**3. As a national senior manager and also scientist -- What do you think are going to be upcoming challenges and BIG changes that are going to come to meteorology and oceanography in Canada?**

We are hearing a lot about "big data" today, and I think this concept is particularly important when dealing with meteorology and oceanography, in Canada generally, but particularly in the Arctic. The new generation of satellites, radar and high resolution models are straining capacity of our federal computer systems and require new ways of working. The next generation of prediction systems at ECCC is very exciting because it will generate an information pool of model data, observed data, and value-added met objects and data which can be further examined and used to develop new data services. Powerful geospatial web services will take next steps toward implementation, data assimilation in models is changing their use, and departments and others will be motivated to mesh with ECCC for data integration into their business. For DND, we will also need to rely on allies for global data, in terms of ships at sea or deployed CAF operations.

A big challenge for Canada will be remote sensing in the Arctic. This will be critical for improving model accuracy. The proposed Polar Communications and Weather (PCW) satellite mission has not achieved federal funding approval yet. I am a big proponent of PCW, as I am concerned about limits that today's polar orbiting satellites have for Arctic weather forecasters, and we need to be ensuring the situation improves and does not deteriorate.

**4. In the past, DND used to have relatively few senior women. What is the situation now?**

Martha Anderson, CMOS President and Arctic Leader

The government of Canada, including DND, has made huge strides in getting women involved in science. I don't worry about gender issues in my daily work. There are lots of female military meteorological technicians (Met Techs) and I have many female peers at the director level. The military has powerful role models such as Lieutenant-General Christine Whitecross who was for a time Commander, Joint Task Force (North), Yellowknife and in 2015 she became the first female promoted to that very senior rank.

**5. As well as being national president of CMOS, you've been a founding member of the Arctic special interest group (Arctic SIG). How did you get interested in the North?**

It started on a personal level actually. My daughter is doing her Master's degree focussing on Arctic sea birds and has spent the last three summers in the Arctic. Beyond this, the thawing of the Arctic has so much potential for change. Understanding changes is a challenge, taking action even more so. Current research and new technology will open a flood gate of data and information that we simply do not have on the Arctic yet. Canada is fortunate to be the caretaker of one of the last frontiers on Earth. Development must be done with care because damage is possible. At the moment, environmental assessments cannot be done properly because data describing Arctic connected ecosystems lacks much of the marine science necessary to describe how changes to the ocean may be reflected in these ecosystems. ArcticNet fills an important role in this regard.

**6. DND is active in a variety of ways in the North. Could you please describe some of these?**

The main roles of DND in the North are surveillance, demonstrating sovereignty, aid to civil authorities when required, and some search and rescue functions. Surveillance is an incredibly challenging task given the size and harsh conditions of Canada's north. The system is made up of a number of components, some delivered by DND, and others by such organizations as the RCMP (Royal Canadian Mounted Police) and Canadian Coast Guard. A few major components in DND include the Joint Task Force North headquarters in Yellowknife which conduct exercises and operations with other organizations, and the facilities such as the north warning system long and short range radar sites. The Canadian Rangers are also a part of DND.

I always like hearing the personal anecdotes of CAF members who have deployed in the North. We have military Met Techs who go on six-month rotations to Alert, who live without any sun and then see it start to appear on the horizon each day. This must be a unique experience. Often southern regular Force members deploy on land-based surveillance treks with local members of the Canadian Rangers. Southerners have their freeze-dried rations, but often end up preferring to eat fresh raw meat with their Northern colleagues. They really value the local expertise and survival skills the Rangers bring.

A challenge for DND is the process of data integration from multiple sensors and vast northern areas into integrated situational awareness products. Defence Research and Development Canada (DRDC) is doing a lot of interesting work in this regard.

**7. How does DND work with Northerners in other areas of METOC science (following on our theme at last year's CMOS on "two ways of knowing")? Are there other lessons learned from DND that could be shared?**

Perhaps the major way that DND works on the ground with Northerners is through the Canadian Rangers. I think it is great that DFO has set up a program where the Rangers are trained and provided equipment to drill holes in ice and take ocean measurements. This data is important for all of us. With challenges of gathering data in harsh Arctic conditions, sharing data is very important. I don't personally work with the Rangers in our military METOC program, but here is a link for more information.

http://www.army-armee.forces.gc.ca/en/canadian-rangers/index.page

A stark reality for me is how melting permafrost has affected the infrastructure for our northern weather instruments at North Warning System sites. I think our Arctic communities and infrastructure such as roads and airfields will need major investments as melting permafrost expands.

**8. What advice would you give to the Arctic SIG on future directions?**

I'm very proud and supportive of the Arctic special interest group as it brings together those interested in the North with a particular focus on meteorology and oceanography. Their support of things like ArcticNet is very important as it assists CMOS in identifying Arctic issues that may be of concern to Canadian policy makers. I wish the group every success in its endeavours and look forward to attending the special session at CMOS Congress in Fredericton in June.

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English version on page 66

## Appel aux membres de la SCMO

Les bénévoles restent la cheville ouvrière de notre organisation. La plupart de nos activités et programmes sont gérés par des bénévoles. Voici où votre aide profiterait le plus à la SCMO :

Fonctions nationales

- Agent de communication ou membre de l'équipe de communication : planification des activités publiques et médiatiques de sensibilisation.
- Président du comité du secteur privé.
- Président ou membre du comité d'agrément des présentateurs météo.
- Membre de l'équipe de planification du 50$^{e}$ anniversaire de la SCMO : participation à la planification de publications ou d'événements spéciaux, de campagnes de promotion ou de financement.

Veuillez communiquer avec moi (president@cmos.ca) si ces fonctions nationales vous intéressent.

Fonctions locales

Les centres de la SCMO cherchent aussi des bénévoles. Vous pourriez aider à organiser un événement, vous joindre au comité exécutif du centre, juger une expo-science ou participer à une autre activité scolaire de sensibilisation.

Communiquez avec l'exécutif de votre centre pour en apprendre davantage sur les possibilités de bénévolat. Sur le site de la SCMO, allez à l'onglet « Centres » puis cliquez sur Centres Executive Directory. Sélectionnez votre centre dans le premier menu déroulant et cliquez sur «Rechercher» pour voir la liste des membres de l'exécutif.

## REPORTS / RAPPORTS

### New research facility to open in Churchill[1]

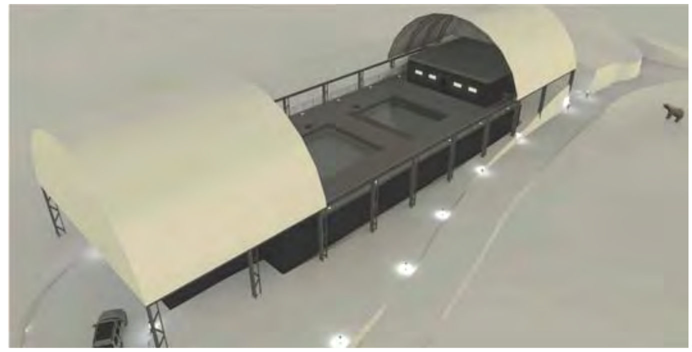
On Monday, July 6, 2015, Shelly Glover, Minister of Canadian Heritage and Official Languages, and Manitoba Premier Greg Selinger, visited Churchill to announce an investment of $22.1 million to build the Churchill Marine Observatory (CMO), a multi-disciplinary research facility where researchers will study the impact of oil spills in sea ice as well as investigate issues facing Arctic marine transportation.

The research infrastructure funding is provided through the Canada Foundation for Innovation's (CFI's) Innovation Fund and Aboriginal Affairs and Northern Development which will invest $12.4 million, and the Province of Manitoba, which has committed almost $9.7 million over four years. The Universities of Calgary and Victoria are also collaborators on the CMO.

The Churchill Marine Observatory will be a unique, highly innovative research facility located in Churchill, Canada's only Arctic deep-water port. The observatory will position Canada as a global leader of research into the detection, impact, and mitigation of oil spills in sea ice. The research will help address technological, scientific, and economic issues pertaining to Arctic marine transportation, oil and gas exploration, and development throughout the Arctic. The project leader is **David Barber**, associate dean of research in the Clayton H. Riddell Faculty of Environment Earth and Resources at the University of Manitoba and Canada Research Chair in Arctic System Science.

David Barnard, President and Vice-Chancellor, University of Manitoba (U of M), notes: "*Arctic system science and climate change is one of the University of Manitoba's Signature Areas of research excellence, and the Churchill Marine Observatory will enable our scientists, working in collaboration with partners around the world, to push forward knowledge and understanding in this important field. Their research will be crucial to mitigating and adapting to the effects of a changing climate on Canada's Arctic and the world.*"

This unique facility will bring together researchers from the universities of Manitoba, Calgary, Victoria, Laval, Dalhousie, and Washington, as well as federal governmental departments. One of its key features will be two saltwater sub-pools designed to simultaneously accommodate various scenarios of oil spills in sea ice. Scientists will be able to study oil in actual Arctic seawater and sea ice. An environmental observing system will also be built on the Churchill estuary, along the main shipping channel across Hudson Bay and Strait, providing a state-of-the-art monitoring system that will strengthen Canada's technological capacity to protect the Arctic environment.



Schematic view of the new facility in Churchill

On September 14, 2007, the European Space Agency stated that ice loss that year had opened up the historically impassable route, setting a new low of ice cover as seen in satellite measurements which go back to 1978. The Northwest Passage became navigable in 2008, and in September 2013, the first large sea freighter MS Nordic Orion was able to use the passage.

The Canadian government considers the Northwest Passage part of Canadian Internal Waters. On July 9, 2007, Prime Minister Harper stated: "*Canada's Arctic is central to our national identity as a northern nation. It is part of our history. And it represents the tremendous potential of our future*." With increasing marine traffic, it is essential that Canada be prepared for the consequences of increased marine shipping traffic.

Barber explains: "*The Churchill Marine Observatory will be a globally unique facility designed to support detailed investigations of oil, and other transportation related contaminants, in Arctic sea ice using a purpose built Oil in Sea Ice Mesocosm (OSIM).These small scale OSIM studies will then be upscaled to the entire Arctic using a highly coupled Environmental Observing (EO) system. Taken as an amalgam the CMO will provide new knowledge and environmental technologies required for the detection, impacts, and mitigation of oil/contaminant spills in sea ice; directly benefitting policy development and technological innovation in Manitoba, Nunavut, Canada, and indeed the circumpolar world*."

[1] Source: University of Manitoba website

Picture caption: Back row (l-r): David Barnard, University of Manitoba President and Vice-Chancellor; Greg Selinger, Manitoba Premier; Shelly Glover, Federal Minister of Canadian Heritage and Official Languages; Mike Spence, Churchill Mayor // Front row: David Barber, Canada Research Chair Arctic System Science, University of Manitoba; Digvir Jayas, Vice-President (Research and International), University of Manitoba; Gerald Farthing, Deputy Minister, Manitoba Education; Norman Halden, dean of the Clayton H. Riddell Faculty of Environment, Earth and Resources.

Arctic System Science and Climate Change is one of the U of M's Signature Areas that are Established Areas of Excellence, and the CMO is a shining example of this Signature Area. The U of M is already home to internationally renowned programs of research in Arctic science, climate change and its effects on Arctic sea ice. During the past 20 years, the U of M has emerged as one of the leading research institutions in the world in the field of Arctic System Science and Technology. At the core of this development is the Centre for Earth Observation Science (CEOS). Through CEOS, the U of M is part of the Arctic Science Partnership (ASP) working together to plan and execute cutting edge research in Arctic science along with the Greenland Climate Research Centre, Greenland Institute of Natural Resources and the Arctic Research Centre, Aarhus University, Denmark.

**The Churchill Marine Observatory positions Canada as a global leader of research into the detection, impact and mitigation of oil spills in sea ice.**

The ASP was made possible in part by $10 million in funding for the Canada Excellence Research Chair (CERC) in Arctic Geomicrobiology and Climate Change, Søren Rysgaard, who is leading a U of M research team at the very forefront of knowledge about the causes and consequences of global warming. Research in this area is crucial to understanding, mitigating and adapting to the effects of a changing climate on Canada's Arctic and the world.

"*With such intense interest in Arctic exploration our CMO researchers will be at the global forefront of predicting the impact of, and response to, oil spills in the Arctic. Their research will inform what needs to be done not if, but when, this happens*," says Norm Halden, dean, Clayton H. Riddell Faculty of Environment, Earth, and Resources, U of M.

## CMOS Accredited Consultant
## Expert-Conseil accrédité de la SCMO

# International Collaboration through International Forum of Meteorological Societies (IFMS)

by Dr. Harinder Ahluwalia

Convener of IFMS Global Meeting Four

Harinder Ahluwalia
IFMS Convener Meeting # 4 and
CMOS Past-President

In today's world where natural disasters are taking bigger and bigger toll on most nations, there is a need for a consolidated effort to create a "*Weather Ready Globe*" (WRG). In August 2014, the World Meteorological Organization (WMO) sponsored World Weather Open Science Conference (WWOSC) in Montreal, Canada. As respective presidents of the Canadian Meteorological and Oceanographic Society (CMOS) and the American Meteorological Society (AMS) at that time, I and Dr. William Gail were asked to cosponsor and organize panel discussions on "*Future of the Weather Enterprise*". These panels were organized by the two of us as well as Dr. Jack Hayes (Chair), Mr. Jim Abraham, and Dr. Brian Mills. Selected moderators and panelists were among "who's who" of the weather business.

During panel discussions, the importance of collaboration between various sectors (public, private, university, non-government organizations, and users) of the weather enterprise and between different nations was stressed. Noting that WMO provides a very important link between various nations through their meteorological services (public sector) and that meteorological societies of different nations provide a link between all five sectors mentioned above, I saw IFMS as a vehicle to achieve the above stated international collaboration.

IFMS was created in 2008 to focus on advancing goals and objectives of the world's professional and scientific societies in the field of hydrometeorology. As per the initial plan, IFMS was intended to be an informal mechanism that facilitated interactions among societies and, as such, would not have any legal or official formalism. Although it is a noble idea, practically it does not work. Nobody appears to have taken initiative to further the cause of IFMS. There has to be some formal structure and follow-up mechanism for IFMS to progress.

"*The fundamental goal of the IFMS is to foster and encourage communication and exchange of knowledge, ideas and resources among the world's more than sixty meteorological societies*". Such exchanges occur only on a bilateral basis or through efforts of the following regional meteorological societies: African Meteorological Society (EAC), European Meteorological Society (EMS), Latino American Federation of Meteorological Societies (FLISMET) and now also through collaboration between the meteorological societies of China, Japan, and Korea (CJK).

With that idea in mind, the Canadian Meteorological and Oceanographic Society (CMOS) and the American Meteorological Society (AMS) cosponsored IFMS Global Meeting Four. This meeting in New Orleans, Louisiana, USA, took place on January 13 (afternoon) and January 14, 2016, concurrently with AMS 96$^{th}$ Conference. The objective of the meeting was to discuss and determine what we would like IFMS to be and how we can make it happen.

The meeting was attended by representatives from national meteorological societies from all six continents. Presentations were made and all three panels were successfully conducted.

All issues we set out to address were discussed and required decisions were made. Global Meeting Four record is provided in both the program book and report which are available on the IFMS website. Those documents summarize the meeting and panels proceedings as well as the results of discussions. The report also provides action items to be acted upon in order to make IFMS a vibrant and operational organization.

With WMO taking care of operations through national meteorological services and International Association of Meteorology and Atmospheric Sciences (IAMAS) taking care of academic exchanges/conferences, IFMS will distinguish itself from these organizations by providing coordination between national meteorological societies, assisting in strengthening developing societies and creating new societies where none exist, producing documents on best practices and value propositions, as well as assisting societies in establishing/strengthening Accreditation/ Certification and Training (ACT) programs. In addition, IFMS is best placed to create collaboration between five sectors of the weather enterprise already defined above.

Participants in Global Meeting Four believed that a strong IFMS was important for leveraging strength of well-developed societies to strengthen developing societies, and help each other to become stronger to help create a "*Weather Ready Globe*".

Major action items fall under the following major categories:

**1**. Organization: appointment of an interim council. Most of its members were proposed at the meeting and the rest of the positions will be filled in the near future.

**2.** IFMS to be a registered/incorporated entity and have a secretariat.

**3.** Strong cooperation between societies to strengthen each other. Developed societies to assist developing societies to strengthen them.

**4.** Preparation of documents related to best practices and value propositions which could be adopted by each society to meet their requirements.

**5.** Assistance in accreditation/certification and training (ACT) programs.

**6.** Defining and organizing IFMS finances.

**7.** Defining and organizing communication requirements.

**8.** Strengthening IFMS website.

The above conclusions of the meeting will be reconfirmed by the interim council through a consultation process.

Hungarian (Magyar) Met Society (MMT) has offered to hold the two-day IFMS Global Meeting Five in Budapest concurrently with the European Meteorological Society's annual meeting which is planned to be held during the period September 3-7, 2018. In addition, MMT will organize its biennial conference in Budapest at the same time.

Some societies (e.g. AMS, CMOS, Norwegian Met Society, etc.) have been able to convince their meteorological departments to provide free data to users to get maximum benefits for the society at large. Through IFMS, these societies can advise other societies interested in achieving this objective, how to go about it.

Many aid agencies of affluent countries and international organizations such as WMO and World Bank (WB) are interested in capacity building in developing countries and least developed countries. They are also interested in making weather ready globe to withstand the disastrous effects of climate change and global warming. Since IFMS is a **volunteer-based organization** that is able to reach all countries of the world through its member societies, a relatively small monetary investment in IFMS by these organizations can provide disproportionately greater benefits to them.

Some seed money (approximately $20 K) from member societies will be required to hire at least an executive director in an affordable country who will be able to help promote IFMS, coordinate its operations and prepare documents related to best practices and value propositions (with the help of council members and their associates). Once operations start in earnest, only then will we be able to find additional means of financing IFMS. Therefore, all member **societies are strongly urged to pitch in!** Let's all work together and reap the benefits of international cooperation.

We would like to profusely thank AMS for doing a wonderful job of making arrangements for the meeting and CMOS for its strong support for this meeting.

Sincere thanks are due to Mary Voice, Elizabeth Bentley, and Jack Hayes, the three panels moderators as well as to the panelists for preparing the reports presented in Annex B, C, and D.

We would also like to thank all delegates who took time out of their very busy schedules to attend this meeting and make it a great success which is demonstrated by progress made at the meeting and emails we have received since then.

***"You must be the change you want to see in the world." Gandhi***

***"Do not take status quo as granted; always think of change for the better." Harinder***

***"No mission is impossible if a dedicated unwavering person or group is prepared to work hard for it." Harinder***

***"Caution is important, but don't let it destroy your ultimate goal." Harinder***

# CELEBRATING 50 YEARS! / CÉLÉBRONS NOTRE 50e ANNIVERSAIRE!

## CMOS 50th CONGRESS
## Fredericton, 29 May to 2 June 2016

CMOS Council and Fredericton congress organizers are very pleased to invite everyone to our 50th congress. This monumental event will represent the beginning of the celebration of the 50th anniversary of the creation of the Canadian Meteorological Society (CMS) on 1 January 1967. In 1975, the President of CMS invited oceanographers to join the society and to organize an oceanographic program for the 9th congress in Vancouver, BC. The congress theme was "*The Role of the Pacific Ocean in the Climate of North America*." Oceanographers became part of the society in 1977 at which time the name was changed to the Canadian Meteorological and Oceanographic Society.

## 50e Congrès de la SCMO
## Fredericton, du 29 mai au 2 juin 2016

Le conseil d'administration de la SCMO et les organisateurs du congrès de Fredericton vous invitent avec grand plaisir à notre 50e congrès. Cet événement grandiose marquera le début des célébrations du 50e anniversaire de la création de la société canadienne de météorologie (SCM), le 1er janvier 1967. En 1975, le président de la SCM a invité les océanographes à se joindre à la société et à organiser un programme sur les sciences de la mer, pour le 9e congrès, tenu à Vancouver (C.-B.). Celui-ci s'intitulait "*Le rôle de l'océan Pacifique dans le système climatique nord-américain"*. Les spécialistes des océans ont pris part à la société en 1977. Ainsi le nom de l'organisation est devenu la Société canadienne de météorologie et d'océanographie.


Names of attendees can be found on the CMOS website under Archives – Le nom des congressistes peut être trouvé sur le site Web de la SCMO sous l'onglet Archives

This is a group photo of the first congress 30 May to 2 June 1967, with fewer than 100 attendees and one program stream. We have grown to a modern CMOS tradition of over 500 attendees and numerous parallel sessions. We hope you can join us for the 50th CMOS congress!

Voici une photo des participants du premier congrès, tenu du 30 mai au 2 juin 1967. Moins de 100 personnes avaient assisté à un programme à volet unique. La tradition s'est étendue à plus de 500 participants par année, profitant de nombreuses séances parallèles. Nous comptons sur votre présence au 50e congrès de la SCMO!

# CELEBRATING 50 YEARS!


## CMOS 50th CONGRESS

## List of sessions

Please note that a full description of sessions is available on CMOS website.

THEME 1: PLENARY

Eight presentations on topics in meteorology, oceanography, and earth sciences from invited plenary speakers.

THEME 2: ATMOSPHERE

**A)** Clouds: Microphysics, Aerosols, and Radiation

**B)** Renewable Energy including solar radiation, wind speed measurements, impact of extreme weathers conditions, wind and solar resource assessment, wind speed, solar radiation, and energy production forecasting, sustainable energy and efficient ways to reduce greenhouse gas emissions.

**C)** Fog or Low Visibility in Atlantic Canada

**D)** Aviation Meteorology and Climatology . This session is of particular interest to those who are in the Aviation Special Interest Group (SIG).

**E)** Environment Canada and the Toronto 2015 Pan Am and Parapan American Games (TO2015 Games) with a selection of various panelists including:

1. David Sills - Science in support of the TO2015 Games. The following four presentations will be 12 minutes each (with three for questions).
2. John MacPhee - Planning, deployment, commissioning, and decommissioning of the mesonet.
3. Martin Elie - Datalogger programming Design, coding, implementation, and issues.
4. Joan Klaassen - Data analysis and inter-comparison from the mesonet compact stations.
5. The Ontario Storm Prediction Centre - Forecast and alerting in support of the TO2015 Games.

**F)** General Atmosphere

THEME 3: CLIMATE

**A)** Climate Variability and Predictability

**B)** Regional climate modelling and diagnostics with a commemoration of the 25th anniversary of the inception of regional climate modelling in Canada.

**C)** Climate Services and Monitoring. This is a general session inviting speakers on topics of climate services and climate monitoring.

**D)** Agroclimatic Extremes- past, present, and future or how extreme weather and climatic events (including disasters) affect the agriculture sector. This session will focus on:

1. Defining. How do we quantify and define extreme weather and climate in agriculture?
2. Monitoring and assessing. What is the baseline?
3. Forecasting. Are extreme weather and climatic indices predictable with a sufficient lead time and skill to allow affected users and decision-makers to make informed choices?
4. Modelling. To what extent are extreme weather and climatic events represented in the Global Climate Models?
5. Communicating. Are extreme weather and climatic events communicated in ways that allow effective and timely use in decision support tools? and,
6. Gaps. What are the uncertainties and gaps in our understanding and knowledge of extreme weather and climate that are preventing us from moving forward?

**E)** Progress in Developing Uncertainty Estimates for Gridded Climate Data

**F)** Climate-carbon cycle interactions (marine and terrestrial)

**G)** Climate Extremes: Drivers and Mechanisms, Today and in the Future

**H)** General Climate

THEME 4: CRYOSPHERE

THEME 5: OCEAN

**A)** Oceanographic High Frequency Radar: Acquisition to Assimilation

**B)** Physical Oceanography

**C)** Monitoring marine ecosystems and climate

**D)** Acoustics in oceanography and marine sciences

**E)** Modelling Tracers in the Ocean with coupling of biological and chemical models to physical ocean circulation models. This session invites papers on all aspects of configuring such models with,
1) best practices for advection, mixing or sinking,
2) how to formulate appropriate air-sea or benthic exchanges,
3) ensuring boundary conditions are consistent between physics and tracers, and,
4) how to make models faster.

**F)** Coastal Oceanography and Inland waters with a special invitation for contributions related to both observational and modelling aspects of biogeochemistry in coastal and inland waters.

**G)** General Ocean

**H)** Collaboration in development, evaluation, and analysis of ocean models. Specific topics will include,

1) optimal design of model domain and grid;
2) sources of model input data;
3) set up and tests of model parameters;
4) improvement in model numerics;
5) interface with sea-ice, atmosphere, and hydrology modules;
6) particle tracking and tracer modules;
7) visualization tools;
8) model validation and datasets;
9) coordinated experiments and inter-comparison;
10) model analysis and scientific issues;
11) strategy for code version control, sharing, and transfer to operations; etc.

**I)** Emerging Arctic Ocean and ocean-atmosphere interactions

THEME 6: SOLID EARTH

**A)** Lithospheric Structure of Eastern North America

**B)** Geophysical signatures of active subsurface processes

**C)** Solid Earth General Session

THEME 7: HYDROLOGY

**A)** Oil Sands Reclamation

**B)** Hot and Hotter: Temperature as an indicator of environmental change and a tracer of hydrologic processes

**C)** Applications of L-Band Microwave Remote Sensing in hydrological monitoring

**D)** Cold Regions Hydrology and Hydrometeorology

**E)** Advances in Hydroecology in Canada

**F)** General Hydrology

**G)** Use of Remote Sensing for Floodplain Characterization

**H)** Urban Water In Canada

**I)** Historical and Projected Changes in Hydroclimatological Extremes: Investigating Roles of Teleconnection Signals and Climate Change

THEME 8: GEODESY

**A)** Integrated Geodetic & Geophysical Monitoring of Earth Systems

**B)** Geodesy and Geodynamics

**C)** Geoid Modelling and Vertical Systems

THEME 9: BIOGEOSCIENCES

**A)** Greenhouse Gas Exchange from Restored or Reclaimed Ecosystems

**B)** Use of Remote Sensing in Arctic Studies

**C)** Use of Remote Sensing for Floodplain Characterization

**D)** Aquatic Transport of Nutrients and Carbon from Agricultural Landscapes

**E)** Impacts of long-term variations and extreme events on winter biogeochemical processes

**F)** General Biogeosciences

THEME 10: EARTH SURFACE

**A)** Land surface modelling for GCMs (General circulation Models) and ESMs (Earth System Models)

**B)** Modelling Earth Surface Processes

**C)** Advances in Earth Surface Processes

THEME 11: INTERDISCIPLINARY

**A)** Hydro-Climatic Extremes and Variability

**B)** Unmanned air vehicles in the earth, meteorological, and oceanographic sciences

**C)** Imaging in the earth, meteorological, and oceanographic sciences

**D)** Atmosphere, Ocean, and Climate Dynamics

**E)** Military Meteorology and Oceanography

**F)** Extraordinary Pacific Ocean and Atmospheric Variations During 2013-2015

**G)** Coupled modelling and the Year of Polar Prediction

**H)** Sensitivity and Uncertainty Analysis (SA/UA) of Earth and Environmental Systems Models. Particular topics of interest include (but are not limited to):

1) Novel methods for effective characterization of sensitivity and uncertainty
2) Implications of SA/UA for model calibration and validation
3) Impact of input data uncertainty on model performance
4) Single- versus Multi-criteria SA/UA
5) Metric specification for model evaluation
6) Improving computational efficiency of SA/UA (efficient sampling, surrogate modelling, parallel computing, model pre-emption, etc.)

**I)** Prediction and Communications of Weather-Related Health Services

**J)** Engaging with the Private Sector. This special session of the CMOS Congress is intended to showcase members and **companies of the** CMOS Private Sector. Contributors are invited to make their pitch about their companies, on the relevance of their work and science as it relates to CMOS in meteorology**,** oceanography with scientific applications that results in a commercial product or service.

## CELEBRATING 50 YEARS!


### CMOS 50th CONGRESS

### List of workshops and special sessions

Please note that a full description of workshops and special sessions is available on CMOS website.

**Workshop #1: Using R for Analysis of Ocean and Atmosphere Data**

Sunday, May 29 **|** 13:00 – 16:30
Room: Devon **|** Cost: $10
Instructors: Clark Richards (clark.richards@rbr-global.com), Dan Kelley (dan.kelley@dal.ca)

**Workshop #2: Using Heat as a Tracer for Hydrology and Groundwater Research**

Sunday, May 29 **|** 10:30 – 16:30
Room: Barkers Point B **|** Cost: $10
Instructors: Barret Kurylyk, PhD, University of Calgary, Jeffrey McKenzie, PhD, McGill University

**Workshop #3: Young Hydrologic Society Workshop**

Sunday, May 29 **|** 10:00 – 16:30
Room: Barkers Point A **|** Cost: $10
Facilitator: Chris Marsh http://chrismarsh.ca/ University of Saskatchewan

**Workshop #4: Campbell Scientific Weather and Water Resource Monitoring Best Practices**

Sunday, May 29 **|** 13:00 – 16:30
Room: Nashwaaksis A | Cost: $10
Instructor: D.J. Snodgrass, Supervisor of Technical Support and Field Services, Campbell Scientific Canada

**Special Session: Arctic SIG Panel Discussion**

Tuesday, May 31 | 13:30 – 15:00
Room: TBD
Facilitator: Helen C. Joseph, HCJ Consulting Helen@hcjconsulting.ca

**Special Session: Engaging with the Private Sector**

Date/Time TBD
Room: TBD
Chair: Martin Taillefer, CMOS Vice President & President of Maritime Way Scientific Ltd.

**Special Session: Environment Canada and the Toronto 2015 Pan Am and Parapan American Games (TO2015 Games)**

Date/Time TBD
Room: TBD
Chair: John MacPhee, Environment Canada, Toronto

**Special Session: Agroclimatic Extremes- Past, Present, and Future**

Date/Time TBD
Room: TBD
Chair: Aston Chipanshi, Agriculture and Agri-Food Canada

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**Next Issue *CMOS Bulletin SCMO***

Next issue of the *CMOS Bulletin SCMO* will be published in **June 2016.** Please send your articles, notes, workshop reports or news items before **May 6th, 2016** to the electronic address given at the top of page 38. We have an URGENT need for your written contributions.

**Prochain numéro du *CMOS Bulletin SCMO***

Le prochain numéro du *CMOS Bulletin SCMO* paraîtra en **juin 2016.** Prière de nous faire parvenir avant le **6 mai 2016** vos articles, notes, rapports d'atelier ou nouvelles à l'adresse électronique indiquée au haut de la page 38. Nous avons un besoin URGENT de vos contributions écrites.

## Proposed Membership Dues Increase

The table shown on next page represents the proposed increase in CMOS membership dues to take effect Jan. 1, 2017:

The last change in membership dues for all types was in 2008. In 2009, student membership dues were reduced from $40 to $20 and will remain as such through 2017. The proposed increase will help to offset the continuously increasing expenditures associated with the CMOS national office operations.

In compliance with Section 3 a) of the Canadian Meteorological and Oceanographic Society By-laws and Appendices the proposed increase will be tabled at the Annual General Meeting in Fredericton.

Gordon Griffith, Ing., P.Eng., FEC
Executive Director
CMOS

## Projet d'augmentation des frais d'adhésion

Le tableau en page suivante indique l'augmentation proposée des frais d'adhésion à la SCMO, avec entrée en vigueur le 1er janvier 2017.

Nous avions modifié les frais d'adhésion pour toutes les catégories de membres en 2008. En 2009, les étudiants avaient vu leur frais d'adhésion passer de 40 $ à 20 $. Ces frais n'augmenteront pas en 2017. La hausse proposée permettra d'éponger les dépenses toujours croissantes associées au fonctionnement du bureau national de la SCMO.

Conformément à l'article 3 a) du règlement de la Société canadienne de météorologie et d'océanographie, l'augmentation proposée sera présentée à l'assemblée générale annuelle de Fredericton.

Gordon Griffith, Ing., P. Eng., FEC
Directeur général
SCMO

**Proposed Membership Dues Increase in CMOS membership dues to take effect Jan. 1, 2017**

| Type | 2009-2016 | | | 2017 | | |
|---|---|---|---|---|---|---|
| | Canada | US | International | Canada | US | International |
| Regular | 80 | 95 | 120 | 85 | 100 | 125 |
| Student | 20 | 35 | 60 | 20 | 35 | 60 |
| Corporate | 160 | 175 | 200 | 170 | 185 | 210 |
| Sustaining | 226 | 241 | 266 | 235 | 250 | 270 |
| Associate | 53 | 68 | 93 | 56 | 72 | 100 |
| Retired | 53 | 68 | 93 | 56 | 72 | 100 |

[1] All values are in Canadian dollars

**Augmentation proposée des frais d'adhésion à la SCMO, avec entrée en vigueur le 1er janvier 2017**

| Catégorie | 2009-2016 | | | 2017 | | |
|---|---|---|---|---|---|---|
| | Canada | É.-U. | International | Canada | É.-U. | International |
| Régulier | 80 | 95 | 120 | 85 | 100 | 125 |
| Étudiant | 20 | 35 | 60 | 20 | 35 | 60 |
| Corporatif | 160 | 175 | 200 | 170 | 185 | 210 |
| Soutien | 226 | 241 | 266 | 235 | 250 | 270 |
| Associé | 53 | 68 | 93 | 56 | 72 | 100 |
| Retraité | 53 | 68 | 93 | 56 | 72 | 100 |

[1] En dollars canadiens

## Call for Volunteers from the CMOS Community

Volunteers are the backbone of this society. Most of our activities and programs are run by volunteers. Here are some areas where CMOS presently needs your help:

National roles:

■ Communications Officer or Communications team member – plan media and public outreach activities.

■ Chair of Private Sector Committee.

■ Chair of Weathercaster Endorsement Committee, or committee member.

■ CMOS 50th Anniversary Planning Team – assist with planning special publications, events, promotions or fundraising.

Please contact president@cmos.ca if you are interested in any of these national opportunities.

Local Roles:

Volunteers are also needed in each CMOS Centre – you could help plan an event, join the local Centre executive, or get involved in science fair judging or other school-aged outreach.

Contact your centre executive to see how you can help out: on the CMOS website under Centres, go to the

http://cmos.in1touch.org/client/relation_roster/clientRelationRosterView.html?clientRelationRosterId=126

Choose your centre's name in the first menu and hit Search to see all the members of your executive.

Note du rédacteur: Vous trouverez la version française en page 55.

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

**Le but de la SCMO est de promouvoir l'avancement de la météorologie et l'océanographie au Canada.**

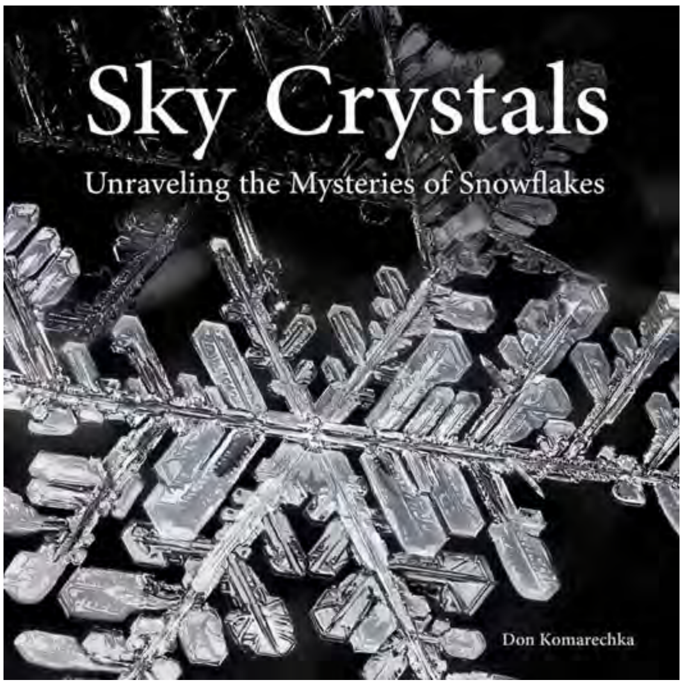
## BOOK REVIEW / REVUE de LITTÉRATURE

### Sky Crystals, Unraveling the Mysteries of Snowflakes

by Don Komarechka

2013, ISBN 978-0-9868204-3-4, $44.99, Printed in Canada, 304 pages, 335 photographs and illustrations

Book reviewed by Kenneth A. Devine[1]




Snowfall as we experience it usually consists of snowflakes which are made up of many ice crystals clumped together but at colder temperatures the individual crystals can be seen. The author and photographer, Don Komarechka, has produced a book filled with vibrant photographs of these ice crystals. Hundreds of images reveal the varied shapes that nature can produce. Falling through atmospheric layers with changing temperatures and humidities these crystals are less than perfect. Different temperature regimes produce different types of ice crystals. This is the real world resulting in the statement that no two ice crystals are alike which comes from the well-known 1931 book of ice crystal photographs by Wilson Bentley.

While Komarechka's book is separated into ten chapters there are really three sections. The first part with references is the physics of how crystals are formed. The second part is the procedure used by the author to photograph and process the resulting images. Finally, after a text filled with photographs it ends with a glossary of crystal pictures which each fill a page.

Different types of ice crystal lattices form at different temperatures and humidities. As crystals form there are internal pressures on the crystal lattices. As well certain areas are favoured for further crystal growth. This could produce a consistent form if the crystal was not falling through different atmospheric layers causing crystals of different types to adhere as it grows. The resulting crystals are still very small but they need about $10^{18}$ water molecules for their formation. The author has carefully detailed the crystal formation and reasons for the deviations.

Since the crystals vary from 0.1 to 10 mm in diameter the author has used a macro lens with a ring light to produce pictures which fill the imager of the camera. But the extremely shallow depth of field requires that multiple images be taken to produce a final image in which all parts of the crystal are in focus. The best field conditions for this photography are when the temperature is less than -15 degrees Celsius and the winds are light. Some researchers such as Bentley have used a camera on a microscope but this means that the crystal has to be kept at ambient temperature while it is carefully moved to the microscope for the photograph. Komarechka uses a knitted black mitten to gently retain the crystal while forty or more images are taken. These images are stacked and processed in Photoshop. Further processing follows to clean up the final image resulting an average time of four hours altogether per image. The processing procedure is complex and not for the faint of heart.

Finally the seventy-eight page glossary of full-page images complements the many pictures within the text. There are near perfect images but the hybrids are the most common. Some start as one type of crystal and then change over to another for the rest of the crystal formation.

The author stated that he funded the production of this book using crowd funding, a novel approach. The book is available on his website which is easily Googled (sky crystals). Author Komarechka has produced an up-to-date view of snow crystals using modern equipment which was only recently available. Anyone interested in the science of ice crystal formation will find this book well worth it both for the scientific explanations and the revealing photographs.

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[1] Meteorological Instrument Consultant, Aurora, Ontario

## Books in search of a Reviewer (Partial list)
## Livres en quête d'un critique (Liste partielle)

Latest Books received / Derniers livres reçus

**2014-5)** *An Introduction to Ocean Remote Sensing*, by Seelye Martin, 2nd Edition, 2014, Cambridge University Press, ISBN 978-1-107-01938-6, Hardback, 496 pages, $88.95.

**2015-3)** *An Observer's Guide to Clouds and Weather, A Northern Primer on Prediction*, by Tony Carlson, Paul Knight, and Celia Wyckoff, 2015, American Meteorological Society and distributed by the University of Chicago Press, ISBN 978-1-935-70458-4, Paperback, 210 pages, US$30.

**2015-4)** Thermodynamics, Kinetics, and Microphysics of Clouds, by Vitaly I. Khvorostyanov and Judith A. Curry, Cambridge University Press, ISBN 978-1-107-01603-3, Hardback, 782 pages, $108.95.

**2015-8)** Radar Meteorology, Principles and Practice, by Frédéric Fabry, 2015, Cambridge University Press, ISBN 978-1-107-07046-2, Hardback, 256 pages, $81.95.

If you are interested to review one of the above book, please contact the Editor.

Si vous êtes intéressés à faire la critique d'un de ces livres, prière de contacter le rédacteur.

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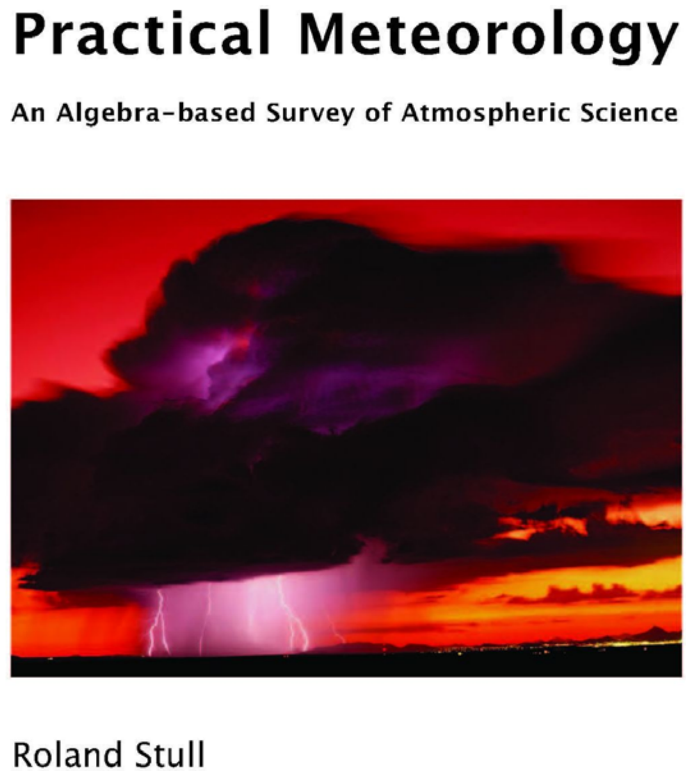


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