ISSN 1929-7726 (Online / En ligne)

CMOS BULLETIN SCMO

Canadian Meteorological and Oceanographic Society

La Société canadienne de météorologie et d'océanographie

August / août 2017

Vol. 45 No. 4

CMOS Bulletin SCMO
Volume 45 No. 4.
August 2017 - août 2017

CMOS Bulletin SCMO

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

Editor / Rédactrice: Sarah Knight
Director of Publications /
Directeur des publications: Douw Steyn

Canadian Meteorological and Oceanographic Society / Société canadienne de météorologie et d'océanographie
E-mail: bulletin@cmos.ca;
Courriel: bulletin@scmo.ca

CMOS Office / Bureau de la SCMO

P.O. Box 3211, Station D
Ottawa, Ontario, Canada, K1P 6H7
Homepage: http://www.cmos.ca
Page d'accueil: http://www.scmo.ca

Gordon Griffith, Ing., P. Eng., FEC
Executive Director - Directeur général
Tel/Tél.: 613-990-0300
E-mail/Courriel: cmos@cmos.ca

Ms. Qing Liao
Office Manager - Chef de bureau
Tel/Tél.: 613-990-0196
E-mail/Courriel: accounts@cmos.ca

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.

Cover Page / Page couverture

Top: Image captured by "Wormcam", a system developed by researchers from Duke University using an outdoor field camera from Campbell Scientific Canada. Wormcam records events at the sediment-water interface in marine environment, recording the numerous microscopic bioturbation events that happen here. This particular image shows a penaeid shrimp preying on a worm. More on page 20 in the advertising feature article by Campbell Scientific Canada. (Image source: Kersey Sturdivant via Wormcam)

Second from top: Photograph shows the Fort McMurray wildfire moving towards Anzac from Fort McMurray on May 4, 2016. The full article *Did anthropogenic climate change increase the chance of an extreme wildfire in the Fort McMurray area?* can be found on page 12. (Image source: Edmonton Journal)

Middle: Curiosity rover selfie taken on the 884th day of its mission - a mosaic of images taken by the rover's MAHLI imager. A side-effect of the mosaicing process is that the rover's arm (where MAHLI is placed) is removed from the final composite image. The full article *Watching the Dust and Clouds Float Lazily by During a Martian Summer* can be found on page 14. (Image source: NASA/JPL-Caltech/MSSS)

Second from bottom: Photograph of a glider operated by the University of British Columbia. This glider was used in the study described in the article on page 17 *Ocean Gliders to Study Baleen Whale Habitat in Roseway Basin*. It was equipped with a CTD, oxygen sensor, and optical sensors for various biological proxies, as well as carrying turbulent microstructure instrumentation to measure turbulence intensity.

Bottom: An extra snowy Vancouver view from Stanley Park. Read the full article *Vancouver Fall and Winter: How Bad Was It?* on page 7. (Image source: Sergeui Mourachov, flickr)

En haut : image prise par la caméra « Wormcam », un système que des chercheurs de l'Université Duke ont construit à partir d'une caméra tout temps de Campbell Scientific Canada. Le Wormcam enregistre des événements, dont de nombreuses bioturbations microscopiques, se déroulant à l'interface sédiment-eau d'environnements marins. Cette image montre une crevette pénéidé s'attaquant à un ver. De plus amples renseignements figurent en page 20, dans l'article promotionnel de Campbell Scientific Canada. (Source de l'image : Kersey Sturdivant par Wormcam.)

Deuxième image : l'incendie de Fort McMurray se déplaçant de cette ville vers Anzac, le 4 mai 2016. L'article complet intitulé « Did anthropogenic climate change increase the chance of an extreme wildfire in the Fort McMurray area? » se trouve à la page 12. (Source de l'image : Edmonton Journal.)

Centre : autoportrait du rover Curiosity pris au 884e jour de sa mission. Mosaïque d'images qu'a enregistrées l'imageur embarqué MAHLI. Un des effets secondaires du processus d'assemblage de la mosaïque fait en sorte que le bras du rover (où se trouve l'imageur MAHLI) est retiré de l'image composite finale. L'article intégral intitulé « Watching the Dust and Clouds Float Lazily by During a Martian Summer » se trouve à la page 14. (Source de l'image : NASA/JPL-Caltech/MSSS.)

Deuxième image à partir du bas : photo d'un planeur océanique qu'exploite l'Université de la Colombie-Britannique. Ce planeur a servi dans le cadre de l'étude décrite dans l'article de la page 17 : « Gliders to Study Baleen Whale Habitat in Roseway Basin ». Le planeur embarquait un CTP, un capteur d'oxygène et des capteurs optiques pour la mesure indirecte de paramètres biologiques, ainsi que de l'instrumentation mesurant les microstructures et servant à déterminer l'intensité de la turbulence.

En bas : manteau de neige exceptionnel sur Vancouver, parc Stanley. Consultez l'article complet intitulé « Vancouver Fall and Winter: How Bad Was It? » en page 7. (Source de l'image : Sergeui Mourachov, flickr.)

Words from the President

Looking Back While Moving Forward

Dear Friends and Colleagues –

In 1980, I left my job in Toronto as a Senior Environmental Scientist with the Ontario Ministry of Environment and moved to Ottawa to join the Water Pollution Control Directorate in Environment Canada (EC). Over the years, I had many opportunities to move out of government, but I always chose to pursue the tremendous science and technology opportunities that presented themselves to a young environmental entrepreneur.

Within a couple of years, I grew to know and utilize a science and technology (S&T) infrastructure that had: 1) strong, supportive leadership at the Deputy Minister (DM) and Assistant Deputy Minister (ADM) levels that had evolved over the previous century; 2) significant resources for funding science and technology; and 3) a large base of science and technology facilities, expertise and experience across a myriad of departments. Training was readily available to learn the ropes of managing S&T and the intricacies of the parliamentary funding and approval process, as well as the staffing process. As I have travelled around the world, I have come to truly appreciate how well Canadians have been served by their dedicated scientists and engineers in the public service.

In my pursuit of funding for oil & gas drilling, production, and refinery regulatory support I discovered the Panel on Energy Research and Development (PERD) and soon found myself Co-Chair of the PERD Offshore Oil & Gas Environment Committee (with Dick Stoddart) and Chair of the PERD Oil Sands/Heavy Oil Environment Committee. I was also a member of some engineering PERD committees and many CMOS members chaired or participated in several other PERD committees. I was managing about $15M a year that at the time was more money than the base budget of the whole of Environmental Protection Service (EPS) in EC. These funds financed meteorological, ice, climate, physical oceanography and fishery R&D work across Fisheries and Oceans Canada (DFO), EC and other departments. Under the mentorship of ADMs like Ken Whitham (Energy, Mines & Resources, EMR) and Jim Bruce (EC) we were charged with building partnerships with the oil industry and universities. We were ultimately able to build an enormous base of long and short term R&D that enabled Canadian policy objectives such as bringing East Coast oil and gas into development in an environmentally responsible manner in a short timeline. Under the (P.E.) Trudeau government, PERD at its peak had over $200M annually. During this period Jim urged me to come out to CMOS Ottawa luncheons. I took him up on the suggestion and have been a member ever since.

From 1983 to 1989 I worked with John Hollins in the Corporate Policy Group of EC as Departmental Coordinator, Energy R&D and Senior Policy Advisor. This included oversight of an energy R&D envelope that had grown to over $25M per year. Among many other activities we developed a proposed structure for expanded funding for environmental science and technology within EC and across departments. This became the blueprint for the S&T component of Canada’s Green Plan under the Mulroney Conservative government. These were exciting times indeed! However, as we moved forward with implementation, Industry Canada (IC) hijacked the proposed Environmental Technology Fund of $100M a year. This funding ended up as the base of Technology Partnerships Canada (TPC) funding programme in IC. Ultimately TPC was terminated by the Harper Conservative government. A large $100M fund for Interdepartmental Environmental R&D was designed along the lines of PERD but was sabatoged by IC in the implementation stage. I have always believed that if this fund had been consummated, it would have made Canada the de facto global leader in environmental science and technology.

From 1989 to 1996, I was Manager of the Technology Transfer Office in EC. We created three not-for-profit Environmental Technology Centres with Green Plan funding, managed EC intellectual property policy, managed the Canadian bilateral programme under the Montreal Protocol and developed joint ventures with the Canadian International Development Agency (CIDA) such as the World Bank Trust Fund for the Global Environment Facility (GEF). Following a one-year leave to work in the private sector, I returned to government to work on Alternative Service Delivery (ASD) to May 1998. I privatized a division of the EC Environmental Technology Centre in Ottawa and worked with David Grimes and his team on ASD options for the weather service. In my view, one of the most successful of the federal ASD ventures from that period is Nav Canada.

Words from the President

In 1997, the Chretien government put together a new programme to start meeting Canada's proposed commitments to dealing with global climate change (the Kyoto Protocol was signed by Canada in April 1998). I was asked to create and direct the technology component of this new plan. With the support of senior management in Natural Resources Canada (NRCan), EC and IC, we developed Technology Early Action Measures (TEAM). Virtually all of the skills that I had learned over my career were drawn upon, as we created a successful "venture fund" within the government. With its lean 5% overhead costs, TEAM provided early financing for over 135 projects in Canada and internationally, with a total value in excess of $1.3 billion from 1998 to 2008. A few examples of major successes include creation of the third largest solar company in the world (Canadian Solar), development of the Toronto deep lake cooling concept into a major utility, complete redesign of the Loblaws store cooling systems, development of new technologies for urban rooftop gardens, net zero housing demonstrations, the Dockside Green project in Victoria, and fuel cell projects with Ford (US), Ballard and Hydrogenics. Our TEAM process streamlined project approvals and significantly improved the actual reduction of carbon. TEAM's measurement and reporting approach established the basis for the International Organization for Standards (ISO) greenhouse gas measurement and reporting standards and the Voluntary Carbon Standard. These standards overcame a major problem with all international "carbon" projects at that time, wherein one UK journalist noted that "…Offsets are an imaginary commodity created by deducting what you hope happens from what you guess would have happened".

Just before and during the decade of TEAM, successive Liberal and Conservative governments significantly reduced government S&T funding and facilities. Generous early retirement packages were provided to the senior S&T leaders in the early 90's and over time the capacity to manage, share, deploy and prioritize S&T across science-based departments declined. The philosophy that remains is that "anyone can manage anything" within a mobile ADM cadre. Massive budget cuts followed and the prism of "public good" was continually abused as a raison d'etre for R&D and technical branch reductions and reorganizations across departments. I'll never forget the way in which one of my Director Generals criticized me for being too entrepreneurial on an annual appraisal! In some cases, as I noted earlier, ASD provided a means to continue programmes and activities.

In the midst of ongoing S&T funding reductions and staff cuts there have also been funds for some new programmes such as TEAM. CMOS itself played a pivotal role in the creation and management of the highly successful Canadian Foundation for Climate and Atmospheric Sciences (CFCAS) that received $60 million in budget 2000. The budget for CFCAS was increased by $50 million in 2003, and the programme was extended to 2011.

To make a long story short: the TEAM fund was not renewed by the Harper government in 2008. After shuttering our Byward Market offices, I retired from the Public Service in 2008. A few years later, the CFCAS funding was not renewed by the same government.

Too often when we demand or develop new programmes to fund S&T (particularly in government), we ignore past mistakes or successes and end up reinventing wheels, or just spinning them. There are enormous demands on government resources, and as CMOS members make public policy interventions on behalf of new S&T resources or programmes, our advice, knowledge and experience must be taken into account to provide the most informed options for moving forward.

Wayne Richardson, P.Eng.
CMOS President

Mot du président

Un regard en arrière pendant que nous avançons

Chers amis et collègues,

En 1980, j'ai quitté mon emploi à Toronto en tant que scientifique chevronné du ministère de l'Environnement de l'Ontario pour joindre la Direction générale de la lutte contre la pollution des eaux à Environnement Canada (EC) à Ottawa. Au cours des années, plusieurs chances de quitter la fonction publique se sont présentées, mais j'ai toujours choisi de poursuivre les opportunités formidables en science et technologie qui s'offraient à moi en tant que jeune entrepreneur en environnement.

Cela n'a pris qu'une couple d'années avant que j'ai appris à me servir d'une infrastructure de science et technologie (S et T) qui avait : 1) un leadership fort et encourageant (qui a évolué au cours du siècle précédent) au niveaux du sous-ministre (SM) et du sous-ministre adjoint (SMA); 2) des ressources d'importance pour financer la science et la technologie; 3) d'importantes assises en matière d'installations de science et technologie, ainsi que d'expertise et d'expérience par-delà un grand nombre de ministères. La formation pour apprendre à maîtriser la gestion de la S et T et les subtilités des processus d'allocation de fonds et d'approbation parlementaires, ainsi que le processus de dotation, était facilement accessible. Mes voyages de part et à travers le monde m'ont amené à développer une appréciation réelle de la façon dont les Canadiennes et Canadiens ont été si bien servis par les dévoués scientifiques et ingénieurs de leur fonction publique.

Au cours de ma poursuite de sources de financement pour le forage, la production, et le soutien de la réglementation des raffineries pétroliers et gaziers, j'ai découvert le Groupe consultatif sur la recherche et du développement énergétiques (GRDE). Rapidement, j'en étais devenu (avec Dick Stoddart) son coprésident du Comité environnemental sur le pétrole et le gaz extracôtiers, et son président du comité environnemental sur le sable bitumineux/pétrole lourd. J'ai aussi été membre de quelques un des comités d'ingénierie du GRDE, et plusieurs membres de la SCMO ont soient présidé ou été membre de divers autres comités du GRDE. J'assurais le gestion annuelle d'environ 15 M$, ce qui représentait, à ce moment-là, une somme plus grande que le budget de base du Service de la protection de l'environnement (SPE) à EC. Ces fonds ont servi à financer la R et D sur la météorologie, la glace, le climat, l'océanographie physique, et la pêche chez Pêches et Océans Canada (MPO), EC, et d'autres ministères. Sous le mentorat de SMA tels Ken Whitham (Énergie, Mines et Ressources, EMR) et Jim Bruce (EC), on nous a confié la responsabilité d'établir des partenariats avec l'industrie pétrolière et les universités. Nous avons pu bâtir une assise énorme de R et D, à long et à court terme, ce qui a permis la réalisation d'objectifs en matière de politique tel le développement, à brève échéance et de manière responsable sur le plan écologique, du pétrole et du gaz de la côte Est. Sous le gouvernement de (P.E.) Trudeau, le GRDE a connu son apogée et assurait la gestion annuelle de 200 M$. C'est au cours de cette période que Jim m'avait encouragé à prendre part aux déjeuners-causeries du centre d'Ottawa de la SCMO. J'ai suivi son conseil et, depuis, je suis membre de la SCMO.

De 1983 à 1989, j'ai travaillé avec John Hollins au Service des politiques du ministère d'EC en tant que coordonnateur du ministère, R et D en énergie et Conseiller de direction principal. Parmi les responsabilités : la supervision d'une enveloppe annuelle de 25 M$ pour la R et D en énergie. Parmi nos activités : le développement d'une structure proposée pour un financement élargi de la science et technologie écologiques au sein d'EC et entre les ministères. Cette dernière est devenue le schéma du volet S et T du Plan vert du Canada du gouvernement Conservateur Mulroney. Décidemment, le moment était excitant ! Malheureusement, pendant que nous allions de l'avant avec la mise en œuvre, Industrie Canada (IC) s'est emparé du fonds proposé de 100 M$. Cette somme a servi plutôt à l'établissement du programme de financement Partenariat technologique Canada (PTC) au sein d'IC. Éventuellement, PTC a été éliminé par le gouvernement Conservateur Harper. Un fonds de 100 M$ pour le R et D interministériels en écologie a été conçu de façon un peu similaire au GRDE, mais lors de la mise en œuvre, IC a saboté le plan. J'ai toujours cru qui si ce fonds avait vu le jour, le Canada serait de fait devenu le pays chef de file en matière de science et technologie écologiques.

De 1989 à 1996, j'occupais le poste de gestionnaire du Bureau de transfert de la technologie à EC. Nous avons créé trois centres de technologie écologique à but non-lucratif grâce au financement fournit par le Plan vert. Nous avons aussi géré la politique de la propriété intellectuelle d'EC. De plus, nous avons géré le programme bilatéral canadien dans le cadre du Protocole de Montréal et nous avons développé des projets conjoints avec l'Agence canadienne de développement international (ACDI) tel le Fonds d'affectation spéciale du Fonds pour l'environnement mondial (FEM) de la Banque mondiale. Suite à un congé d'un an au cours duquel j'ai eu un emploi dans le secteur privé, je suis rentré au secteur public pour travailler sur la diversification des modes de prestation de services (DMPS) jusqu'en mai 1998. J'ai privatisé une division du Centre de technologie environnementale d'EC à Ottawa et j'ai travaillé avec David Grimes et son équipe sur des options de DMPS pour les Services météorologiques. Selon moi, NAV CANADA représente l'un des projets de DMPS les mieux réalisés de cette époque.

En 1997, le gouvernement Chrétien a conçu un nouveau programme ayant pour but de concrétiser les proposés engagements du Canada afin de lutter contre le changement climatique mondial (le Canada a signé le Protocole de Kyoto en avril 1998). On m'a demandé de concevoir et de diriger le volet technologique de ce nouveau plan. Grâce à l'appui des cadres supérieurs de Ressources naturelles Canada (RNCan), d'EC et d'IC, nous avons développé le programme de Mesures d'action précoce en matière de technologie (TEAM). J'ai dû faire appel à presque toutes les compétences que j'ai acquises au cours de ma carrière lorsque nous créions ce fructueux fonds de capital-risque au sein du gouvernement. Tout en réussissant à conserver les coûts indirects à 5% de son budget, de 1998 à 2008, le programme TEAM a fourni un financement précoce à 135 projets au Canada et à l'international, ayant une valeur supérieure à 1,3 G$. Quelques exemples de grand succès incluent la création de la troisième entreprise solaire au monde (Canadian Solar), le développement du concept du refroidissement de lac profond de Toronto pour faire de celui-ci un service public important, la refonte complète des systèmes de refroidissement des magasins Loblaws, le développement de nouvelles technologies pour les jardins toiture-terrasse en milieu urbain, des démonstrations de logement à consommation énergétique nette zéro, le projet Dockside Green à Victoria, et des projets de pile à combustible avec Ford (États-Unis) et Ballard Power and Hydrogenics. Le processus du programme TEAM a simplifié l'approbation de projets et a nettement amélioré la réduction réelle du carbone. L'approche de mesure et de rapport du programme TEAM a établi les bases des normes de mesure et rapport des gaz à effet de serre de l'Organisation internationale de normalisation (ISO) et la Norme de carbone volontaire. Ces normes ont permis de surmonter un problème majeur commun à tous les projets internationaux de carbone de ce temps. Un journaliste du Royaume-Uni a noté que « …Les crédits de carbone sont une commodité imaginaire résultant de la soustraction de ce que vous espérez arrivera de ce que vous estimez aurait pu arriver ».

Au moment qui précédait le décennie du programme TEAM, et pendant celle-ci, des gouvernements Libéral et Conservateur successifs ont grandement réduit le financement gouvernemental de la S et T, ainsi que le nombre d'installations qui y étaient dédiées. Au début des années 90, les dirigeants principaux de la S et T ont reçu de généreuses offres de retraite anticipée, et avec le temps, il y a eu un déclin de la capacité de gérer, partager, déployer, et prioriser la S et T au sein de ministères dans lesquels la science jouait un rôle primordial. La philosophie qui demeure est que « n'importe qui peut gérer n'importe quoi » au sein d'un cadre de SMA mobiles. Des coupures budgétaires importantes ont suivi et on a abusé continuellement du prisme du « bien public » en tant que raison d'être pour les réductions et réorganisations de la R et D et des services techniques parmi divers ministères. Je n'oublierai jamais la façon dont un de mes directeurs généraux m'a critiqué parce que j'étais trop entreprenant lors d'une évaluation annuelle ! Dans certains cas, tel que j'en ai fait note auparavant, la DMPS résultait en un moyen de poursuivre certains programmes et activités.

Au milieu de ces incessantes coupures de fonds pour la S et T et réductions de personnel, il y a eu des fonds disponibles pour de nouveaux programmes tels TEAM. La SCMO a joué un rôle essentiel lors de la création et de la gestion fructueuses de la Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA) qui a été dotée de 60 M$ dans le budget 2000. L'enveloppe de la FCSCA a grandi de 50 $M en 2003 et la durée de programme a été étendue jusqu'en 2011.

Pour faire bref : Le financement du programme TEAM n'a pas été renouvelé en 2008 par le gouvernement Harper. Suite à la fermeture de nos bureaux du Marché Byward, j'ai pris, en 2008, ma retraite de la fonction publique. Quelques années plus tard, le même gouvernement n'a pas renouvelé le financement de la FCSCA.

Trop souvent, lorsqu'on exige ou développe de nouveaux programmes pour financer la S et T (particulièrement au sein du gouvernement), nous ignorons les succès et erreurs du passé et nous nous retrouvons en train de réinventer la roue (ou bien de les faire tourner vivement en faisant du surplace). Il y a de lourdes pressions sur les ressources gouvernementales, et au fur et à mesure que les membres de la SCMO font des interventions sur la politique publique afin de sécuriser de nouveaux programmes et ressources de S et T, notre conseil, savoir et expérience doivent être pris en compte afin de fournir les options les plus éclairées pour continuer notre avancée.

Wayne Richardson, P.Eng.
président, SCMO

Article: Vancouver Fall and Winter 2016/17

Vancouver Fall and Winter 2016/17 - How Bad Was It?

P. Odon, G. West, R. Stull; Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia

The fall and winter seasons of 2016/17 were noteworthy for the cold, wet weather they brought to regions of British Columbia (BC). Although all of BC experienced some impacts, the South Coast region saw particularly large impacts from an exceptionally wet fall that quickly transitioned into a persistently cold, snowy winter. This paper will provide an overview of the weather and impacts of the fall, then winter seasons.

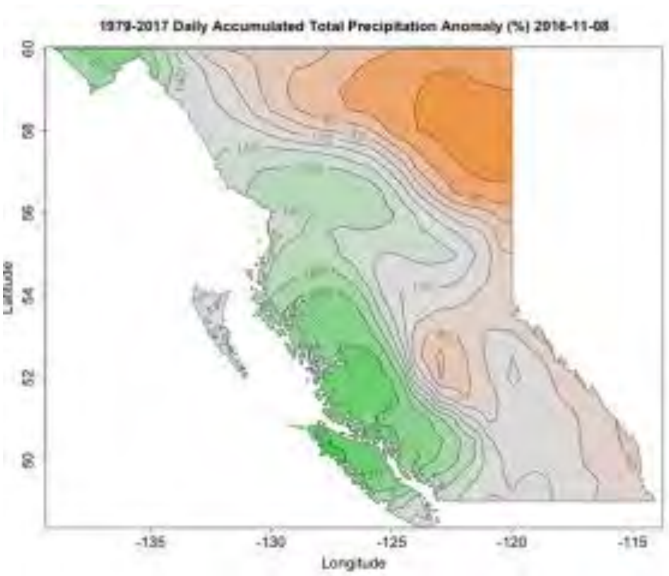


Figure 1. Fifteen-day accumulated precipitation anomaly centered on November 8th, 2017, relative to 1979-2017 period. Data from the ERA-Interim [1].

Fall 2016 across BC's South Coast

October saw significant snow accumulations at mid to high elevations, and record rainfall amounts in many low-elevation areas across the South Coast. Temperatures warmed to record levels ahead of an atmospheric river event on November 8th, 2016. Many daily records were set, with new monthly records of 19.4°C in Vancouver and 22.4°C in Abbotsford (see Fig. 8 for all mentioned locations). The combination of record warmth and rain-on-snow led to large snowmelt contributions to runoff, in addition to the heavy rainfall itself.

Figure 1 illustrates the fifteen-day precipitation anomalies for the first half of November. In several locations of the Coast it precipitated 200% more than normal.

For the province's primary electric utility, BC Hydro, the situation made for challenging reservoir operations, balancing dam safety requirements with minimizing downstream flooding. Although most reservoirs across the South Coast were full or near full, the most concerning was the Campbell River system. The upper part of the watershed received the normal November monthly precipitation in the first eight days of the month [2]. Furthermore, one-week and two-week reservoir inflows set new records, and were estimated to exceed 1-in-100 year volumes.

In emergency coordination calls and meetings, BC Hydro worked with nearby towns, regional districts, and the province, deciding to increase discharges to a record-tying 600 m^3s^{-1}, enough to fill an olympic-sized swimming pool every four seconds. This was done to mitigate the risk of overtopping the dam in subsequent storms, which would've meant passing the full reservoir inflows (1100 m^3s^{-1}), flooding communities downstream [2].

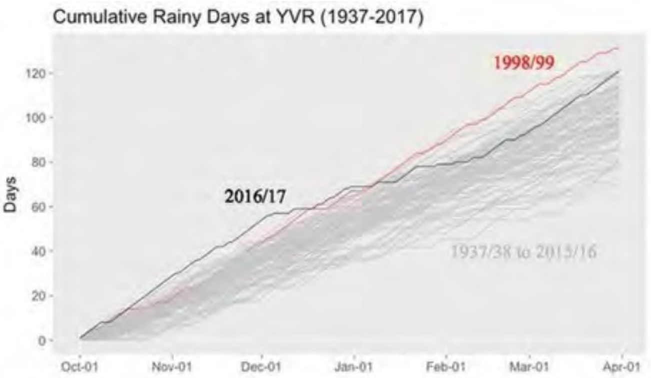
At Vancouver International Airport (hereafter, Vancouver) there were only three days without rain in October and only two in November (Fig. 2). In fact, the fall and winter 2016/17 period had the second highest frequency of rain since 1937/38, with 121 days of rain during the 182-day (6-month) period (Fig. 2). Only the 1998/99 period was higher, with 131 days of rain. Furthermore, this 2016/17 period featured 22 *consecutive* days of rain (October 12th – November 2nd; Fig. 3). This was the longest stretch in the past five years, and the ninth longest since 1937/38.

Winter 2016/17, Arctic Outbreaks

In December the pattern abruptly became much cold and drier. Five arctic air outbreaks brought anomalous cold temperatures, and snow to British Columbia in December through February.

Figure 4 shows the 15-day average minimum 2-m temperature anomaly across British Columbia centered on second arctic outbreak on December 11th, 2016. It shows the difference between what British Columbians would expect for that time of year and what actually happened. Temperatures were much colder than average, with much of BC more than 10°C below normal.

Article: Vancouver Fall and Winter 2016/17



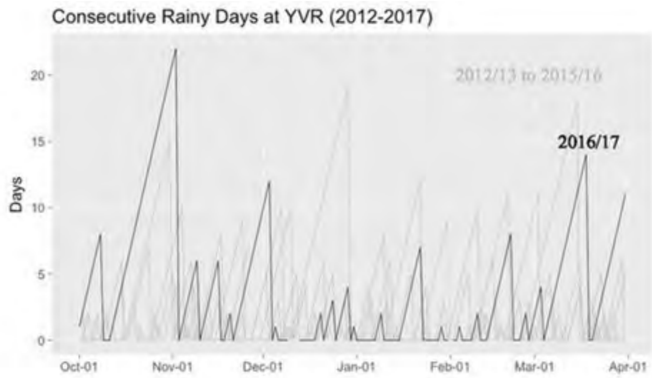
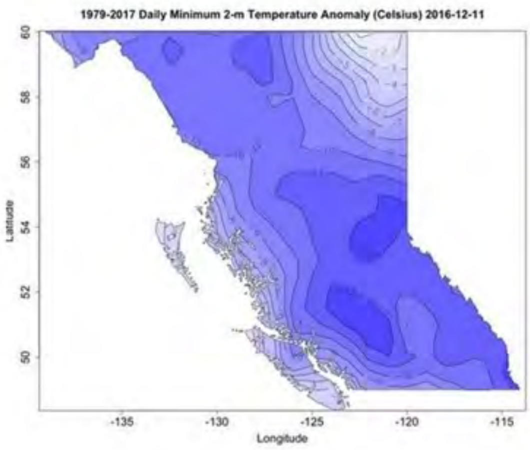


Figure 2 (on left). Cumulative number of rainy days at Vancouver International Airport. Time series for all years between 1937/38 and 2016/17 in grey, 1998/99 in red and 2016/17 in black.
Figure 3 (on right). Consecutive rainy days at Vancouver International Airport for the past 5 years in grey, with fall/winter 2016/17 in black.

In Vancouver, daily minimum temperatures were below freezing for most of December, January and the first part of February. This period was colder than winters in recent memory (5-year average, red line in Fig. 5) and the long term average (80-year average, blue line in Fig. 5). There were 54 days of below freezing daily minimum temperature during the entire 6-month period, more than any such period since 1992/93 (orange line in Fig. 5).

The five arctic outbreaks can be identified in the smoothed minimum temperature time series by the large departures from the 80-year average, occurring on approximately December 5th and 11th, 2016, January 1st and 10th, 2017 and February 2nd, 2017; most followed by snow days (Fig. 5).



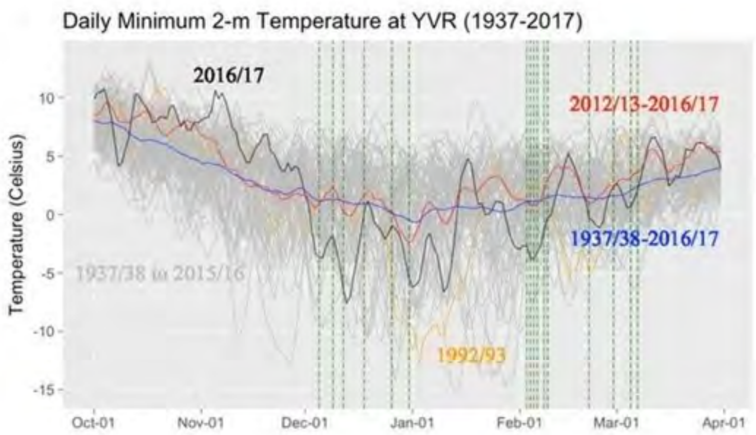


Figure 4 (on left). Fifteen-day averaged minimum 2-m temperature anomaly centered on December 11th, 2016, relative to 1979-2017 period.
Figure 5 (on right). Daily minimum 2-m temperature time series for Vancouver, smoothed using a 5-day rolling window for readability. Time series for all years in grey, 1937/38-2016/17 average in blue, 2012/13-2016/17 average in red, 1992/92 in orange and 2016/17 in black. Days with snowfall indicated with green dashed lines.

These weather events directly impacted the general population as well as government and industry. Garbage was left uncollected for weeks in neighbourhoods of Vancouver, Burnaby, Surrey and Delta [3,4] due to persistent snow and ice cover in alleys and lanes.

Across Metro Vancouver, many side streets and sidewalks were left uncleared and unsalted. Residents had difficulties simply getting around the city and questioned the Vancouver Mayor’s commitment to the issues [5]. Nearby cities also experienced salt shortages, rationing their supplies. Stores and wholesalers were also having trouble meeting the demand [6].

By the end of December, the city of Vancouver had spent $2.5 million on snow and ice reduction, triple the amount used in the previous two winter periods combined [6]. Even after the unusual cold winter, Vancouver still needed to address the nearly 15,000 potholes (almost double than normal) affecting drivers [7].

Long waits, cancellations and delays also left commuters questioning Vancouver's public transportation system readiness for such cold winter weather [8] (Fig. 6a). Additionally, strong arctic outflow winds over the Salish Sea during the outbreaks led B.C. Ferries to cancel sailings, impacting ferry commuters [9].

Figure 6(a) Public transit buses paralyzed by road conditions during the December 11th, 2016 arctic outbreak [11]. (b) A Google Maps screen capture, where orange and red colours indicate widespread very slow or stopped traffic during the February 3rd, 2017 arctic outbreak.

During the arctic outbreaks, approximately $5 million was spent to operate an ice-clearing cable collar system on the Port Mann Bridge — the province's primary east-west corridor for both commercial and commuter traffic. By contrast, just $300,000 was spent to operate it in 2015/16. Lane closure due to crews clearing the bridge and Highway 1 led to major traffic problems during the last arctic outbreak on February 3rd, 2017 [10] (Fig. 6b).

During the third arctic outbreak on January 3rd, 2017, BC Hydro set a new record for power consumption, breaking the old record set on Nov 29th, 2006 [12]. Finally, in the last outbreak in early February, a storm cycle brought record-breaking snow and freezing rain to the Fraser Valley. Abbotsford observed 57.8 cm of snow [13] and there were reports of up to 80 cm in Chilliwack [14]. Freezing rain accumulated 2-4 cm [15]. 361,000 BC Hydro customers lost power [16] and Vancouver was cut off from the rest of BC with highways 1, 3, 5 and 99 all closed [17]. The large-scale features providing the atmospheric context of these intense arctic outbreaks will be described next.

Anatomy of an Arctic Outbreak

The five arctic outbreak events were each comprised of a cold continental airmass associated with a strong arctic high pressure system in Alaska and the Yukon, combined with a warmer, moist air mass associated with a Pacific low pressure system. The lows played an important role in producing periods of snow across the South Coast.

In far northern latitudes, during winter the sun angle is low or below the horizon. This means incoming solar radiation is very limited, while outgoing radiation from the earth's surface continues unabated. This creates a negative surface energy budget and the air cools, building very cold airmasses at the surface. Such airmasses are associated with strong high pressure like that seen over Alaska and the Yukon during the first outbreak between December 4th, 2016 and December 6th, 2016 (blue shading in Fig. 7a, and red sea level pressure contours in Fig. 7b).

The cold, dense, stable airmass flows through valleys, fjords, and straits on its way to Vancouver, partially blocked by the higher mountainous terrain of British Columbia (Figs. 7c and d). Where the valleys, fjords and straits widen, the cold air spreads and thins, accelerating into arctic outflow winds [18]. An example is shown in a fine-resolution computer model forecast for the second arctic outbreak on December 12th (Fig. 8). These outflow winds have impacts of their own, like the cancelled B.C. Ferries sailings in the Strait of Georgia mentioned in the previous section.

Article: Vancouver Fall and Winter 2016/17

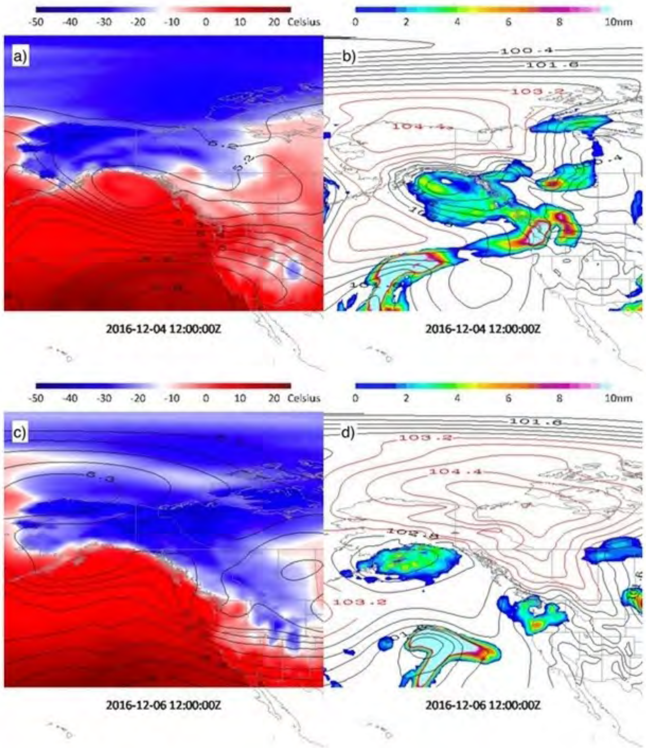


Figure 7. (a) 50.0-kPa geopotential height (km) and 2-m temperature (°C), (b) sea level pressure (kPa) and 6-hr precipitation (mm) for December 4th, 2016 at 1200 UTC. (c) and (d), as in (a) and (b), but for December 6th, 2016 at 1200 UTC.

Figure 8. A fine-resolution computer model wind forecast for December 12th, 2017 at 1300 UTC. Vector orientation shows direction, colour shows speed. Terrain is grey-shaded. Geographic locations mentioned in text shown with red labels, highways labelled in white.

Often an arctic outbreak event will draw to a close with the approach of a Pacific low pressure system ushering in moist, mild air. In the December 5th outbreak, an upper level low over the Gulf of Alaska moved southward down the coast (Figs. 7a and c). With low-level arctic air in place, the upper-level trough and associated surface low pressure brought 5-15 cm of snow across the South Coast, with 5.4 cm measured in Vancouver (Figs. 7c and d). While this is relatively little snow compared to snowfalls in other parts of Canada, it caused major disruptions.

Summary – Vancouver fall and winter 2016/17, how bad was it?

We've presented an overview of the weather and impacts of the fall/winter 2016/17 seasons at BC's South Coast. The fall season was abnormally wet for multiple months, especially in terms of frequency of precipitation. This culminated in an early November storm cycle that caused headaches for emergency management personnel, and featured greater than 1-in-100-year cumulative flows for parts of Vancouver Island. Subsequently we discuss the anatomy of an arctic air outbreak, and showed that a series of five such outbreaks led to a well-below-normal winter, and an abnormally large number of days with below-freezing minimum temperatures. The result was a 6-month period of weather that, by the metrics discussed herein, was the worst in recent memory, and among the worst in history for the South Coast of BC.

References

[1]Dee, D. P., Uppala, S. M., Simmons, A. J., Berrisford, P., Poli, P., Kobayashi, S., Andrae, U., Balmaseda, M. A., Balsamo, G., Bauer, P., Bechtold, P., Beljaars, A. C. M., van de Berg, L., Bidlot, J., Bormann, N., Delsol, C., Dragani, R., Fuentes, M., Geer, A. J., Haimberger, L., Healy, S. B., Hersbach, H., Hólm, E. V., Isaksen, L., Kållberg, P., Köhler, M., Matricardi, M., McNally, A. P., Monge-Sanz, B. M., Morcrette, J.-J., Park, B.-K., Peubey, C., de Rosnay, P., Tavolato, C., Thépaut, J.-N. and Vitart, F. (2011), *The ERA-Interim reanalysis: configuration and performance of the data assimilation system*. Q.J.R. Meteorol. Soc., 137: 553–597. doi:10.1002/qj.828

[2] BC Hydro (Nov 18, 2016). *Record inflows, but limited downstream flooding, thanks to BC Hydro operations and some luck.* Retrieved from https://www.bchydro.com/news/

[3] Correia, C. (Dec 28, 2016). *Winter conditions testing patience of Lower Mainland residents*. Retrieved from http://www.cbc.ca/news/canada/british-columbia

[4] McElroy, J. (Dec 15, 2016). *Extended cold snap putting a strain on services throughout Metro Vancouver*. Retrieved from http://www.cbc.ca/news/canada/

[5] Laanela, M. (Jan 05, 2017). *Vancouver mayor absent as councillor calls for snow removal inquiry*. Retrieved from http://www.cbc.ca/news/canada/british-columbia

[6] City of Vancouver (Jan 04, 2017). *City crews continue work to remove remaining snow and ice*. Retrieved from http://vancouver.ca/news-calendar/news.aspx
[7] CTV Vancouver (Mar 30, 2017). *Wicked winter leaves behind 15,000 potholes in Vancouver*. Retrieved from http://bc.ctvnews.ca/
[8] McElroy, J. (Jan 06, 2017). *Vancouver in its longest cold snap in over 30 years*. Retrieved from http://www.cbc.ca/news/canada/british-columbia
[9] Brend, Y. (Dec 04, 2016). *BC Ferries cancels sailing due to 'severe weather' as winter chill hits*. Retrieved from http://www.cbc.ca/news/canada/british-columbia
[10] Saltman, J. (April 3, 2017). *BY THE NUMBERS: Winter's costly impact on Alex Fraser and Port Mann bridges.* Retrieved from http://vancouversun.com/news/
[11] Fritz, W. Y. (Dec 20, 2016). *Winter is no reason to mind your manners* in @WinnieYeo [Twitter]. Retrieved from https://twitter.com/winnieyeo?lang=en.
[12] Paetkau, J. (Jan 04, 2017). *Record breaking power usage as cold snap continues*. Retrieved from http://www.cbc.ca/news/canada/british-columbia
[13] Environment and Climate Change Canada. *Historical Climate Data*. Retrieved from climate.weather.gc.ca
[14] Macmahon, M. (Feb 06, 2017). *Fraser Valley hit hardest by snowfall, more on the way*. Retrieved from http://www.news1130.com/
[15] Meuse, M. (Feb 09, 2017). *Fraser Valley weather the worst veteran CBC cameraman has ever seen.* Retrieved from http://www.cbc.ca/news/canada/british-columbia
[16] Luymes, G. (Feb 11, 2017). *Winter storm blows over in time for Family Day*. Retrieved from http://vancouversun.com/category/news/local-news/
[17] McElroy, J. (Feb 10, 2017). *Weather closes every highway linking Lower Mainland to rest of B.C.*. Retrieved from http://www.cbc.ca/news/canada/british-columbia
[18] Jackson, Peter L. (1996), *Surface winds during an intense outbreak of arctic air in Southwestern British Columbia.* Atmosphere-Ocean, 34:2, 285-311. doi: 10.1080/07055900.1996.9649566

About the Author: Pedro Odon

Pedro is a PhD Candidate in Atmospheric Sciences at UBC. He is developing a website for BC Hydro to forecast extreme weather events taking into account climate change. Previously, he was a school teacher in Mathematics in Brazil, Argentina and the United States.

Article: Climate Change and Fort McMurray Wildfires

Did Anthropogenic Climate Change Increase the Chance of an Extreme Wildfire in the Fort McMurray Area?

Megan Kirchmeier-Young, Pacific Climate Impacts Consortium, University of Victoria

A summary of a recent paper by Kirchmeier-Young et al. that describes an event attribution analysis to quantify the increase in seasonal metrics of extreme wildfire risk for a region in western Canada.

High impact extreme events, like the large wildfire near Fort McMurray, Alberta in May 2016, often prompt questions regarding the role played by human-induced climate change. The answer to such questions can be found using event attribution. The methodology for event attribution and current status of research in this area are summarized in a report released by the American National Academies of Science, Engineering, and Medicine (NASEM) last year [1].

Event attribution typically sets out to identify the contribution of human influence to the probability of occurrence of a given extreme event by comparing sets of climate model simulations with natural climate influences only and with both anthropogenic (human) and natural influences. A common parallel comes from the field of epidemiology. Just as the presence of certain behavioral or environmental factors can increase the likelihood of a person developing a particular disease, the presence of anthropogenic emissions can increase the likelihood of a particular climate extreme.

A recent study by Megan Kirchmeier-Young, Francis Zwiers, Nathan Gillett, and Alex Cannon published in Climatic Change (DOI:10.1007/s10584-017-2030-0) performs an event attribution analysis to investigate the contribution of human emissions to extreme fire seasons in a region in western Canada that includes Fort McMurray.

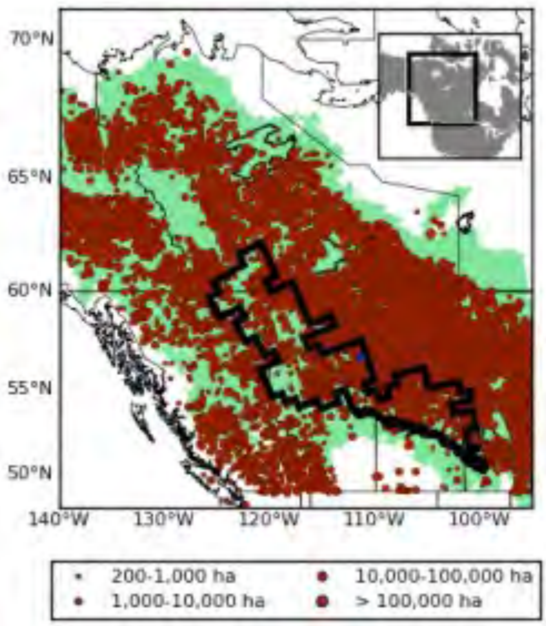


Figure 1: Map showing the locations of large fires in western Canada, 1980-2014.

To set the stage, in Canada, around 2.1 million hectares are burned each year, on average with most large fires being ignited by lightning [2]. Figure 1 displays the locations of large fires in western Canada during 1980-2014, which occur predominately in the boreal zone. Numerous studies have projected increases in fires or fire risk in North America with increased greenhouse gases (e.g., [3,4,5,6]) and this is of concern for both fire management agencies and communities in high-risk areas.

This study utilized large ensembles of the CanESM2 model, developed and run at Environment and Climate Change Canada's Canadian Centre for Climate Modelling and Analysis. The analyses of these ensembles is a core contribution of the Canadian Sea Ice and Snow Evolution (CanSISE) Network project. It includes ensembles of 50 realizations of the full earth-system model that utilized all forcings, which includes both the natural (solar and volcanic) and anthropogenic (greenhouse gases, aerosols, land-use, ozone, etc.) components. Each realization in the ensemble should represent the same "forced" signal due to the external influences listed above, but each realization will contain different random variations about that signal that reflect the natural chaotic variability of the climate (i.e., the so-called butterfly effect). Using a large ensemble, here 50 realizations, should capture most of this internal variability. In addition, a second ensemble contains 50 realizations of the model that utilize only natural factors. All of the model data were downscaled to a higher spatial resolution, to better represent influences of the topography in the region, and bias corrected towards a dataset based on observations.

To provide a broad assessment of fire risk, temperature, relative humidity, wind speed, and precipitation from the model data were used to calculate indices from the Canadian Forest Fire Danger Rating System (CFFDRS). CFFDRS indices are used widely across Canada by fire managers and researchers to describe the availability of burnable fuels and potential fire behaviour. For this study, the CFFDRS indices were summarized using the 90th percentile value of each index during the fire season; the 90th percentile is the value exceeded by only 10% of days and it provides a measure of the general severity of each index for the year. Metrics describing the number of days each season with high potential for fire spread, as well as indicators of the fire season start, end, and length were also used. All metrics were summarized for the homogeneous fire regime zone [7] that contains Fort McMurray (black outline in Figure 1).

For each metric described above, a threshold was chosen to designate an extreme level and the probability of exceeding this threshold in a fire season was calculated from the large ensembles for both all and natural-only forcing. Data from 2011-2020 were used to represent the current climate. A “risk ratio” is calculated to compare the probability of each event between the all and natural-only ensembles. The risk ratio is a simple ratio of the probability of an extreme fire season under all conditions to the probability of an extreme fire season under natural conditions; the resulting value describes how many times as likely an extreme fire season would be as a result of the anthropogenic component.

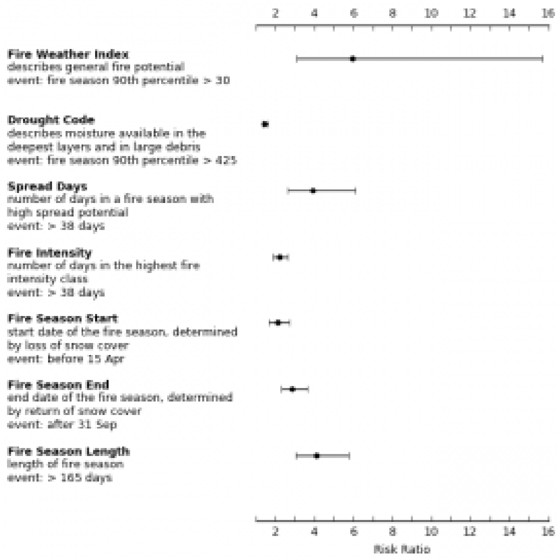


Figure 2: Risk ratio for various metrics. For each metric listed, the risk ratio value and uncertainty is shown. A risk ratio exceeding 1 indicates that anthropogenic forcing increases the probability of the event in question.

Figure 2 summarizes the risk ratio results for a few of the metrics based on Table 2 of the described paper. For each metric listed, the risk ratio value is shown with the point and the whiskers extending to each side indicate the uncertainty on this value. For example, a fire season lasting longer than 165 days is about 4 times as likely when anthropogenic influences are included, though this ranges from 3 times to almost 6 times as likely. A risk ratio exceeding 1 indicates that anthropogenic forcing increases the probability of the event in question and this is observed for all metrics. Finding an anthropogenic contribution to increased fire risk for many different types of metrics increases confidence in the event attribution. For the metrics shown here, and most other metrics shown evaluated in the paper, anthropogenic forcing experienced to date results in extreme fire risk events being 1.5 to 6 times as likely.

The results demonstrate that, based on the climate model utilized here, the Fort McMurray fire of 2016 occurred in a world where fire seasons often start earlier and last longer, where there is a general increased risk of extreme fire potential, and where there are a higher number of potential spread days that can result in the growth of a large fire. These increased fire risks are the result of anthropogenic influences.

Given the current wildfire situation in BC, one may wonder about the influence of human emissions on fire risk in other regions of western Canada. The landscape in BC is different from the region described in this study and will require different considerations in the calculation of the indices as well as in the choice of metrics and thresholds. The authors are currently working on extending the above work to answer this question.

References:

[1] NASEM 2016, DOI: 10.17226/21852
[2] Natural Resources Canada, http://cwfis.cfs.nrcan.gc.ca/home
[3] Flannigan et al. 2009, DOI: 10.1111/j.1365-2486.2008.01660.x
[4] Flannigan et al. 2013, DOI: 10.1016/j.foreco.2012.10.022
[5] Wang et al. 2015, DOI: 10.1007/s10584-015-1375-5
[6] Wotton et al. 2009, DOI: 10.1071/WF09002
[7] Boulanger et al. 2012, DOI: 10.1071/WF11073
[8] Brandt 2009, DOI: 10.1139/A09-004

About the Author: Megan Kirchmeier-Young

Megan is a Post-Doctoral Fellow at the Pacific Climate Impacts Consortium at the University of Victoria. As part of the Canadian Sea Ice and Snow Evolution (CanSISE) Network, she has been working on the attribution of extreme events.

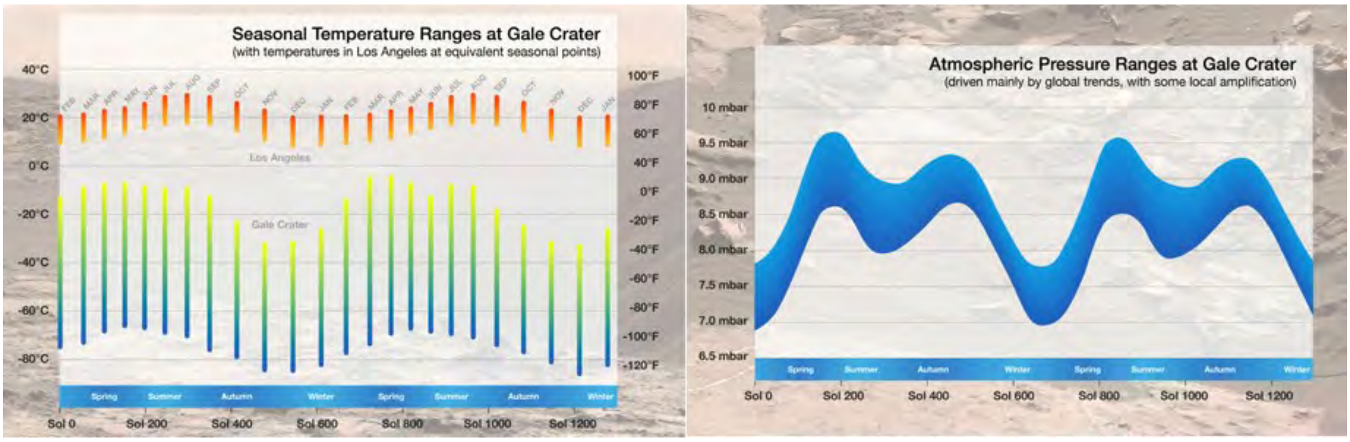
Article: Martian Summer Atmosphere

Watching the Dust and Clouds Float Lazily by During a Martian Summer

John E. Moores, Christina L. Smith and Charissa L. Campbell, York University

A scientific rover named Curiosity has been trundling around on Mars for the past 5 years, taking images of the atmosphere to look at clouds and dust. Because of data constraints, our group at York University get about 12 minutes of time every week or so. Imagine trying to understand the weather by looking at only one section of the sky once a week through a toilet paper tube! Despite these limitations, between our work and that of other scientists and spacecraft, we have been able to put together a robust picture of what the martian environment is like.

Near the surface, the martian atmosphere is a dry, cold and low-pressure place beset by UV irradiation, not unlike the upper terrestrial stratosphere. Near the equator, daytime surface temperatures may rise as high as -10ºC during the summer, with the surface rocks getting as hot as +30ºC. However, the nights are punishing. Though the atmosphere is nearly pure CO_2, with an average of only 610 Pa of pressure, infrared cooling means that the temperature can fall nearly 100ºC. If not for our RTG, the rover would be challenged to survive these nights. However, luckily the weather is relatively light. With such low pressures, it is difficult to generate sufficient gradients to drive strong winds and most weather is local (see the excellent piece by Peter Taylor et al. in the April 2009 edition of The Bulletin). Yet there are seasonal changes. At -123ºC, the atmosphere itself begins to freeze out, driving a 30% change in the atmospheric pressure over the martian year and depositing a meter of CO_2 on the winter cap down to ~60ºN. We also see moving sands driven by the occasional winds and fossilized dunes and ripples from when the martian atmosphere was much thicker and warmer (Lapotre, Science, 2017).



Seasonal cycles as measured at Gale Crater by the Curiosity Rover using its Rover Environmental Monitoring Station (REMS). Source: NASA/JPL-Caltech/CAB(CSIC-INTA)

Mars Dust

The surface of Mars is very dry and desert-like, meaning that it is home to vast quantities of dust which can get whipped up into the atmosphere from the surface and can reach very high altitudes. Because the atmosphere is so thin on Mars, only limited Rayleigh scattering occurs (scattering of light by atmospheric molecules that causes the sky to be blue during the day and the sunsets to be red in our own atmosphere). With no light scattering at all, the sky would appear black. However, the martian atmosphere's abundant dust particles scatter the light, giving it a pinkish hue during the day and spectacular blue sunsets.

Dust is so important to the martian environment that the seasons can be defined in terms of a dusty and a clear season. That's not to say there is no dust present in the atmosphere during the clear seasons, there's just less of it! The dusty season happens during the southern hemisphere's spring and summer – sometimes during very dusty times, Curiosity is unable to see the edge of the crater it's in. Dust devils are frequently seen by Opportunity and Curiosity, especially during the dusty seasons, and sometimes we see several dust devils at once!

Of course a dry and desert-like environment isn't complete without a dust storm or two. Local dust storms can happen at any time in the martian year, and are restricted to a (relatively) small area. Global dust storms, the likes of which we don't see on Earth, only happen during the martian dusty season and happen on average every 2-3 martian years. The effect on the whole planet is visible from orbit: the surface gets completely obscured by dust lifted from the surface and gradually clears over several months as the dust is dropped back onto the surface.

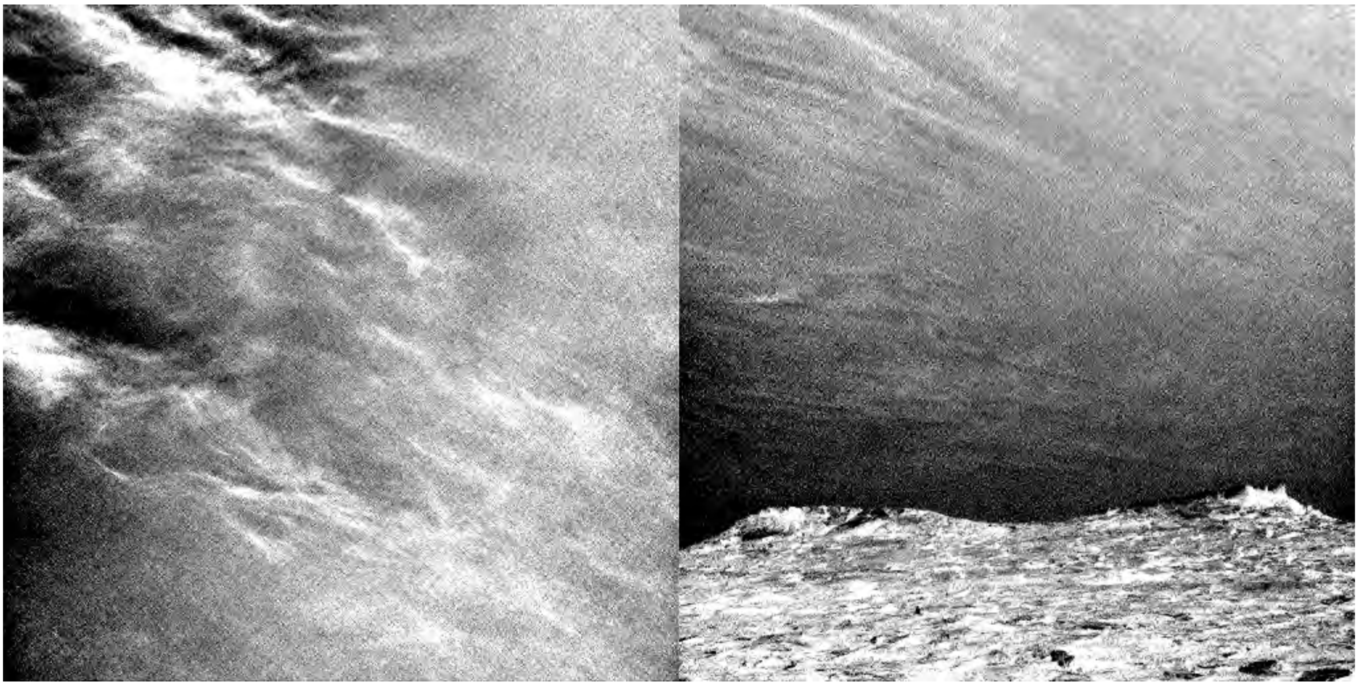
Article: Martian Summer Atmosphere

We can also look at dust on a more local scale. With Curiosity we can look at the amount of dust in different regions of Gale Crater, which can tell us about atmospheric circulation occurring in and around the crater.

If you like dust – Mars is the place to be!

Mars Clouds

When people think of the atmosphere of Mars, they might not realize that clouds actually flow over Gale Crater. They resemble cirrus clouds here on Earth and are so thin that if you were to stand in Curiosity's shoes (or wheels!), you'd most likely not see them. This is due to the extremely thin atmosphere on Mars where the average optical depth is 0.02 (Kloos et. al, 2016) . To put this in perspective, the human eye can see optical depths greater than 0.04. Therefore, the majority of the clouds that we do get to witness at Gale Crater would be invisible to any human explorers. Unlike here on Earth, Mars' atmosphere cannot retain enough water-ice particles to have significant cloud cover, especially over an equatorial region like Gale Crater. In fact, if you were to condense out the entire atmospheric column of water vapour onto the surface, you would get a layer less than 0.1 mm thick, even on the wettest and cloudiest day!



Two images representing a single frame of the different atmospheric movies taken by Curiosity in July 2017. The left is the Zenith movie (straight above the rover) while the right is the Supra-horizon movie (just above the crater rim). Mean-frame subtraction technique is used to retain these from the raw images. In both images, wispy cirrus-like clouds are present that could be at high altitudes due to the similar behaviour of cirrus clouds here on Earth. Source: NASA/JPL-Caltech/York University.

Just like on Earth, Mars has seasons – it even has a recurring one for clouds. This cloudy season is known as the Aphelion Cloud Belt and shows significantly more clouds in our atmospheric movies than any other time of the year. In fact, the dustiest and cloudiest seasons happen to be at opposite times of the Martian year. During the cloudy season, Mars is approaching aphelion which cools down the atmosphere allowing any water-ice particles to condensate onto dust grains.

To see these martian clouds, we take two types of observations with Curiosity that consists of 8 images sewn together to create an atmospheric movie. They are known as Supra-horizon movies (SHM) and Zenith movies (ZM). The main difference between them is the angle of the camera that the images are taken at. SHMs are taken just above the crater rim and ZMs show the atmosphere directly above the rover. One question that is always asked: how do you know those are clouds? Well, we look for a general shape within our atmospheric movies. If the features tend to stay together and move across the frame simultaneously, they would be representative of clouds, like how clouds here on Earth behave. Dust has also been seen in our movies and tends to have chaotic movements, making it identifiable as dust rather than clouds. A great example of what clouds on Mars actually looks like is shown in the following atmospheric movies.

Article: Martian Summer Atmosphere

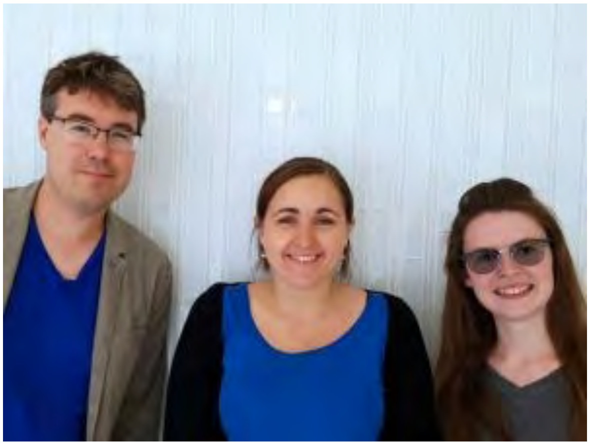
Is Mars a habitable place?

NASA's Curiosity Rover captured this blue martian sunset on the 956th martian day of its mission. The four images were taken over the course of 6 minutes 51 seconds and were taken with the Rover's Mast-Cam. Source: NASA/JPL-Caltech/MSSS/Texas A&M Univ.

Over the years, many have speculated on whether Mars' environment could be engineered to be more Earth-like. This presents a geo-engineering challenge for which there is no parallel. Fundamentally, Mars has three problems. First, there's not enough energy to go around. No matter how high you boost the CO_2 pressure, it isn't possible to generate enough of a greenhouse effect to get the average surface temperature above freezing. Our work with exoplanets has shown us that pure hydrogen could do the job and we may yet find a more reasonable gas cocktail to do the trick, but that just highlights the second problem: Mars is extremely poor in volatile gasses. Beyond the CO_2, there's just a hint of Nitrogen and Argon and almost no water – Mars's high D/H ratio of 5.5 x VSMOW is a testament to its lost ocean. Perhaps you could generate oxygen, baking it out of the dust and rock on an industrial scale, but you'd have to import the needed buffer gasses and water in bulk from comets. Even if you do succeed in creating a habitable atmosphere on Mars, you would encounter the third problem: it would be ephemeral. Low gravity equates to high atmospheric escape rates. Your atmosphere wouldn't be the first that Mars has let slip through its fingers.

In the end we're forced to conclude that we would be much better off trying to solve our own problems on Earth rather than moving on to the next world. You may ask – why then go to Mars? Some will cite exploration or to inspire our children to take up science. But there are also benefits for an atmospheric scientist. By examining such extreme conditions, we get a window on how our theories hold up when taken far past their validation points. Several of our presenters at the 2017 CMOS Congress were doing just that – using an atmospheric model developed by Environment Canada to predict Canadian weather to examine the weather on Mars. Ultimately, by finding explanations that work under both martian and terrestrial conditions, we gain a clearer window into the fundamental science that animates both atmospheres.

About the Author: John Moores



John is an Assistant Professor in the Department of Earth and Space Science and Engineering at York University. He has served on the CMOS Scientific Committee since 2014 and represents the society on the Canadian Space Agency's Planetary Exploration Consultation Committee. John is pictured here with team members Christina Smith (centre) and Charissa Campbell.

Article: Gliders for Studying Whale Habitat

Ocean Gliders to Study Baleen Whale Habitat in Roseway Basin

Tara Howatt[1] Tetjana Ross[2], Stephanie Waterman[1]
[1]University of British Columbia, [2]Institute of Ocean Sciences

Canadian coastal waters are interspersed with baleen whale habitats, some of which are well known and protected, while others have yet to be identified and characterized. The Whale Habitat and Listening Experiment (WHaLE), funded by Marine Environmental Observation Prediction and Response (MEOPAR), is an initiative dedicated to deepening our knowledge of rare and threatened baleen whales and helping to protect them from ship strikes. This project is a collaboration involving Dalhousie University, Fisheries and Oceans Canada, Ocean Tracking Network (OTN), University of Victoria, University of British Columbia (UBC), and Woods Hole Oceanographic Institute. A goal of this project is to use autonomous underwater gliders to identify and characterize baleen whale habitat in Canadian coastal waters.

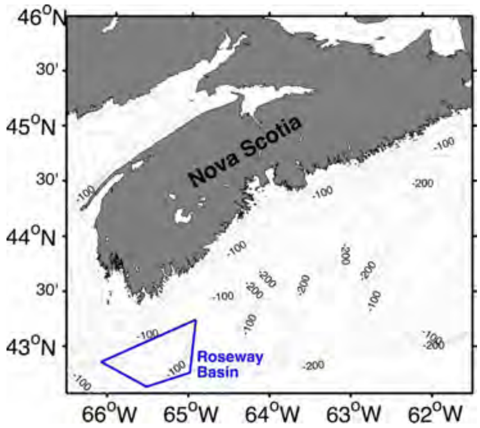


Figure 1: Map of Nova Scotian coastal waters (bathymetry in grey contours and depth in m) with Roseway Basin Critical Habitat outlined in blue.

Roseway Basin, Nova Scotia (Figure 1) is a known and protected whale habitat: the Southeastern margin of the basin in particular has historically had a large number of right whale sightings [Vanderlaan et al., 2008; Davies et al., 2013]. What is it that makes Roseway Basin good habitat and why, in particular, is the Southeast margin favoured? There is still much to be learned about exactly what characteristics and/or oceanographic processes at play make this region attractive to whales, and why similar basins on the Scotian Shelf are less habited [Davies, et al., 2013; Moore, 2017].

Perhaps the whales are following the food; right whales primarily feed on diapausing Calanus finmarchicus (copepods) [Brown, et al., 2009], and fin whales are known to feed on euphausiids [Heise et al., 2007]. It is hypothesized that zooplankton aggregating processes, such as fronts [Franks, 1992] and/or turbulence [Fuchs and Gerbi, 2016], are occurring in the basin, making whale food abundant and highly concentrated.

Figure 2: On left is the OTN glider with hydrophone, echosounder, and CTD shown. On right is the UBC glider with turbulence profiler shown.

Fronts, characterized by strong horizontal gradients in water properties, are known to typically be very biologically productive regions. This can be due to their role in segregating different water masses with different water properties and different zooplankton assemblages [Sournia, 1994; Powell and Ohman, 2015], or by creating plankton convergence zones through the interaction of the circulation associated with the front and certain zooplankton swimming behaviours [Franks, 1992].

The presence of enhanced ocean turbulence can have different effects on zooplankton distributions depending on the circumstance. In some cases, it supports zooplankton populations by increasing zooplankton feeding rates of smaller plankton, while in other situations, it stresses zooplankton populations by promoting zooplankton

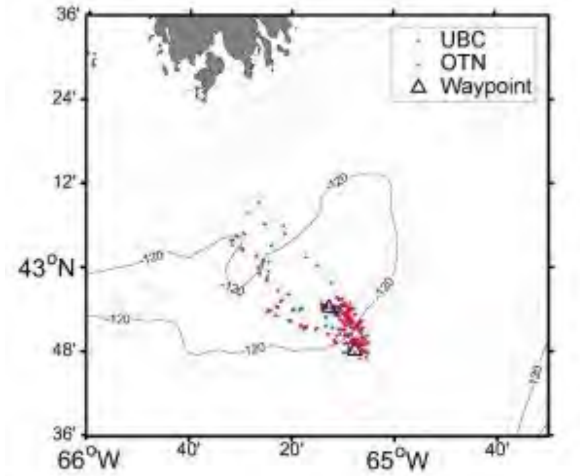


Figure 3: Map of 2017 glider tracks on Southeast slope of Roseway Basin.

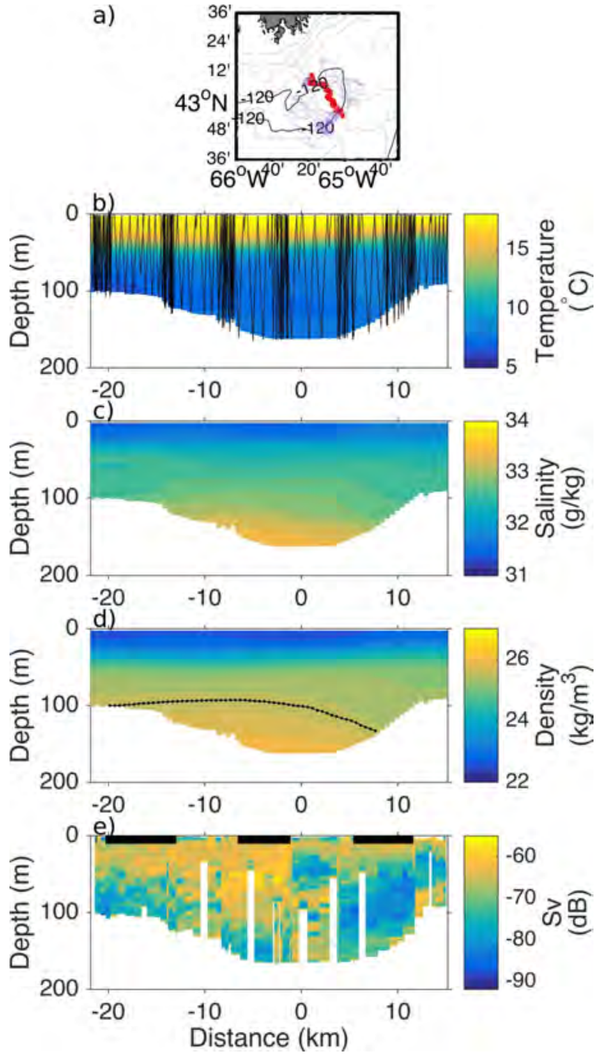


Figure 4: a) Map of 2015 Roseway Basin glider deployment in blue, cross-basin section used in b-e shown in red, b) conservative temperature with glider profiles superimposed, c) absolute salinity, d) density (colour) with 1025.5 kg/m3 isopycnal (black) superimposed, e) Scattering volume (Sv) with black bars at the top indicating nighttime sampling.

predation by larger organisms [Rothschild and Osborn, 1988]. Turbulence can also stress zooplankton by eroding the feeding currents they generate or by increasing their pursuit time of prey [Kiørboe and Saiz, 1995].

To examine the influence these physical processes have on the zooplankton distribution in Roseway Basin, we are using underwater gliders, autonomous drone-like instrument platforms which dive and climb in the water column, collecting data in a saw-tooth pattern for several days (Figure 2). Gliders are revolutionizing how we can observe the ocean by collecting substantial high-resolution, long-duration datasets of multiple ocean state metrics via a wide range of sensor payloads. Recently we have had two such gliders deployed in the basin, doing repeated transects on the Southeast slope (Figure 3). One, operated by the Ocean Tracking Network, is equipped with a hydrophone to listen for whale calls, a 300 kHz echosounder to estimate zooplankton abundance, a CTD to measure temperature and salinity, an optode to measure dissolved oxygen concentration, and a series of optical sensors for measuring chlorophyll fluorescence, backscatter, and irradiance. A second glider, operated by the University of British Columbia (shown in header image), was also equipped with a CTD, oxygen sensor, and optical sensors for various biological proxies. In addition, it carries turbulent microstructure instrumentation to measure turbulence intensity.

Glider measurements in Roseway Basin have been ongoing since 2014, but this is the first time a glider-mounted turbulence profiler has been used in this region. With strong tidal currents on the basin margin, we anticipate that this will be a very dynamic and turbulent region. Flying two gliders in tandem provides a unique opportunity to study the relationship between turbulence, zooplankton distribution, and whale presence. Further, past deployments have focused on mesoscale processes on scales of kilometers to tens of kilometers. This recent deployment has dedicated a week of sampling time to do repeated, shorter (13 km) transects of the Southeastern slope to characterize smaller scale processes like turbulence and submesoscale dynamics, and to capture the temporal variability of fronts.

On this mission, these two gliders have collected a total of 15 slope transects. We have observed density fronts indicated by the slope of the 1025.5 kg/m3 isopycnal (Figure 4), and the presence of dense water (>1026 kg/m3) that originates on the Scotian Slope and typically carries diapausing copepods [Head, et al., 1999; Davies et al., 2013]. We have observed that how the fronts are positioned on the basin slope varies due to the strong tidal currents in the area.

The UBC glider was recently successfully recovered, while the OTN glider is continuing to sample the full extent of the basin for another three months. When it's done, the two gliders together will deliver a unique data set that allows us to study both meso- and submeso-scale processes in Roseway Basin, and further work towards bridging the gap between physical and biological oceanography.

Article: Gliders for Studying Whale Habitat

Acknowledgements: We would like to thank Adam Comeau, Jude Van der Meer, Sue L'Orsa, and Richard Davis from the Ocean Tracking Network for all the hard work they put into the glider deployments. We also appreciate the work of Chris Payne and Benjamin Scheifele on the UBC glider team. We also thank Kim Davies, Hansen Johnson, and Chris Taggart for their expertise and leadership on the East coast WHaLE project. We thank Gennavieve Ruckdeschel for providing the echosounder data used in Figure 4. This work is funded by MEOPAR and 20 partnering organizations, which are listed here: http://meopar.ca/research/project/whale-whales-habitat-and-listening-experiment.

References

Brown, M. W., D. Fenton, K. Smedbol, C. Merriman, K. Robichaud-Leblanc, and J. D. Conway, 2009: Recovery Strategy for the North Atlantic Right Whale (Eubalaena glacialis) in Atlantic Canadian Waters [Final], Fisheries and Oceans Canada. vi + 66p.

Davies, K. T. A., T. Ross, and C. T. Taggart, 2013: Tidal and subtidal currents affect deep aggregations of right whale prey, Calanus spp., along a shelf-basin margin. Mar. Ecol. Prog. Ser., 479, 263–282.

Franks, P. J. S., 1992: Sink or swim: Accumulation of biomass at fronts. Mar. Ecol. Prog. Ser., 82, 1–12.

Fuchs, H. L. and G. P. Gerbi, 2016: Seascape-level variation in turbulence- and wave- generated hydrodynamic signals experienced by plankton. Prog. Oceanogr., 141, 109–129.

Head, E. J. H., L. R. Harris, and B. Petrie, 1999: Distribusion of Calanus spp. on and around the Nova Scotia Shelf in April: evidence for an offshore source of Calanus finmarchicus to the central and western regions. Can. J. Fish. Aquat. Sci., 56, 2463–2476.

Heise, K., J. Ford, and P. Olesiuk, 2007: Appendix J: Marine mammals and turtles. Ecosystem overview: Pacific North Coast Integrated Management Area (PNCIMA), B. G. Lucas, S. Verrin, and R. Brown, Eds., 2667: iv + 35p.

Kiørboe, T. and E. Saiz, 1995: Planktivorous feeding in calm and turbulent environments, with emphasis on copepods. Mar. Ecol. Prog. Ser., 122, 135–145.

Moore, D., 2017: Is Emerald Basin, Scotian Shelf, Canada, a North Atlantic right whale (Eubalaena glacialis) feeding habitat? Honours Thesis, Dalhousie University. 1-63 pp.

Powell, J. R. and M. D. Ohman, 2015: Changes in zooplankton habitat, behavior, and acoustic scattering characteristics across glider-resolved fronts in the Southern California Current System. Prog. Oceanogr., 134, 77–92.

Rothschild, B. J. and T. R. Osborn, 1988: Small-scale turbulence and plankton contact rates. J. Plankton Res., 10 (3), 465–474.

Sournia, A., 1994: Pelagic biogeography and fronts. Prog. Oceanogr., 34, 109–120.

Vanderlaan, A. S. M., C. T. Taggart, A. R. Serdynska, R. D. Kenney, and M. W. Brown, 2008: Reducing the risk of lethal encounters: vessels and right whales in the Bay of Fundy and on the Scotian Shelf. Endang. Species Res., 4, 283–297.

About the Author: Tara Howatt

Tara is currently working on her PhD in physical oceanography at the University of British Columbia. She is using underwater gliders to investigate the physical processes involved in creating whale habitat.

Advertising Feature: Images & the Environment

A Picture is Worth a Thousand Words: How images can answer our questions about the environment

A Campbell Scientific Advertising Feature

"What caused this unexpected spike in my data?"
"My sensor is offline – did something knock it over?"
"If only I could see for myself what the current conditions are."
"I wish I had visuals to support the story the data is telling me."

Anyone monitoring their environment has thought something like this at one time or another, and wished they could obtain a visual confirmation for peace of mind. Thanks to the evolution of outdoor camera technology, now we can.

The employment of cameras as independent monitoring devices is quickly becoming standard practice. Capturing real-time data on changes to infrastructure and the environment represents a sound, cost-effective, user-friendly asset and risk management tool. Due to technological advances in cameras, the collection of real-time data in the form of high-resolution still images and/or video (with GPS capability) is now possible. Cameras can be setup nearly anywhere and connected to a data logger and solar power supply to capture data in the form of images. Image acquisition can be triggered through various mechanisms, including internal timers, motion detection, web page control, or an external device (i.e. accelerometer, strain gauges) via a data logger, or supplied as a continuous live feed. With this array of activation, storage, and low power capabilities, cameras are suitable for just about any data-gathering situation.

Stemming from increased demand for independently operating cameras in remote locations, Campbell Scientific Canada (CSC) offers a series of rugged, outdoor field cameras that help clients capture change events in a wide variety of applications and environments.

Images and the Environment I: Bridge Crashes on the I-65

Virginia Avenue bridge impact event. Source: Purdue University S-BRITE Center

Event-triggered image capture can be used to provide decision-makers with visual confirmation of an event. When the Indiana Department of Transportation (INDOT) received an increased number of bridge impact reports on the Virginia Avenue Bridge over the I-65 near Indianapolis, they contemplated a major bridge rehabilitation to correct a reduced under-clearance. The reduced distance between the pavement overlay and underside of the bridge was the inadvertent result of a previous infrastructure project. The problem was that the proposed rehabilitation would be costly, and some doubted that the number of reported impacts were numerous enough to justify both the cost of rehabilitation and the substantial traffic interference due to construction. INDOT suspected there were more events than being reported, but what they needed was data. How many impacts? What type of impacts? How significant were they? Was this really a problem? To address this need, INDOT teamed up with an engineering group at Purdue University to develop a web-based monitoring interface. The objective was to monitor impact events at the Virginia Avenue Bridge. In order to capture still images (site metadata) and video (impact event), they used a high-resolution Campbell Scientific CC5MPX digital outdoor camera. The system operated autonomously, providing real-time notification of impact events through email and text messaging, accompanied by high definition video footage of an impact event. The results were impressive: from the images and video collected, INDOT's suspicions of under-reporting of impact events were confirmed. As a result, INDOT was able to convince stakeholders, including the public, that repair of under-clearance was indeed necessary. For INDOT and the public, images held the answers to their questions.

Advertising Feature: Images & the Environment

Images and the Environment II: Wormcam Captures Marine Environments

Images are also extremely useful for time-based studies; time lapsed videos provide interesting visualizations of changes over time often in inherently difficult places to study. One example is from Duke University where a group of researchers developed Wormcam to record events at the sediment-water interface in marine environments. Real-time images of the numerous microscopic bioturbation events at the sediment-water interface are captured in situ. These video compilations allow for robust insight into processes at the sediment-water interface, which provides an understanding into these intricate, microscopic events. These videos are used in further research initiatives and education in schools from primary to university. A plethora of interesting Wormcam videos can be viewed at http://www.youtube.com/channel/UCWVoJ-b4wsPekeM9lVSrlmg.

Wormcam images, from left to right: mud crab in its burrow; an Oyster Toad Fish (Opsanus tau) peering into Wormcam; a penaeid shrimp preying on a worm. Source: Kersey Sturdivant via Wormcam

Images and the Environment III: Snow Line Monitoring in Rogers Pass, Alberta

Rogers Pass, Alberta, Canada

Additionally, there are various government bodies using cameras to monitor snow line altitudes and current conditions in mountain ranges and valleys that are notorious for their micro-climates. CSC recently worked with Parks Canada on one such monitoring effort. Public safety and accessibility are year-round concerns for Parks Canada operators, as avid skiers flock to Alberta's mountain ranges throughout the winter, and hikers and mountain climbers travel to the area as temperatures rise in the spring. And while springtime temperatures and clear skies may indicate favorable conditions, snow lines may still be too low on the mountains for many outdoor activities. To provide visual confirmation, an outdoor CCFC camera was installed at the west end of Glacier National Park looking east to Rogers Pass, Alberta, providing a single full view of the valley, with the ability to zoom in on mountaintops above the valley. Parks Canada is able to provide the general public with real-time views of Rogers Pass. A feed from the camera is available on the Parks Canada website, with a new image available every half hour. Now the general public can stay informed of current snow line altitudes within Rogers Pass, and use these real-time views as supplemental information to weather forecasts for the area to ensure their planned activities are safe.

Considering the versatility of cameras and the influence of the images and videos they produce, it's clear how powerful they are as asset and risk management tools, and for research. The images and video gathered can be used to inform decision-makers on impending safety issues including flooding, avalanches, and road conditions. Data in the form of images are also being gathered and studied by scientists and researchers to enhance their understanding of earthly phenomena in places that were previously inaccessible to visualization. It is the unbounded opportunity to see something that has never been seen that will continue to drive our limitless collection of image data.

Environment and Climate Change Canada | Environnement et Changement climatique Canada

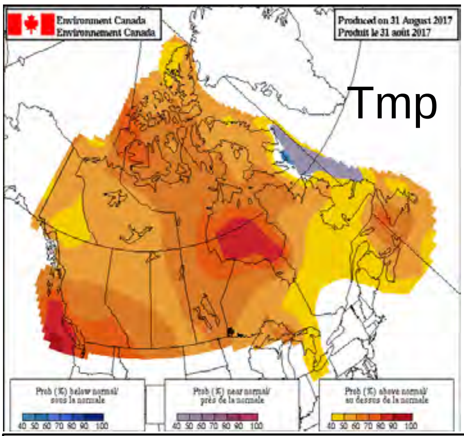
Canada

Seasonal Outlook for the autumn 2017 (SON) based on CanSIPS forecast issued on the 31st August 2017

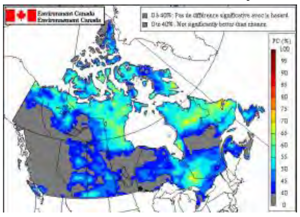
M. Markovic and K. Gauthier

Above normal autumn is expected across Canada. Above normal temperatures are likely to occur everywhere in the continental Canada. The highest probabilities (70% and +) for above normal forecast are over the Hudson Bay, Coastal BC and western Canada. Northern QC, northern ON and MT, Great Lakes region and coastal BC have more than 60% probability for an above normal autumn.

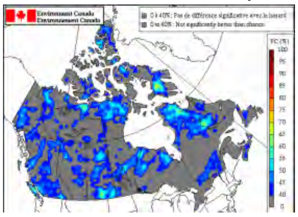
Equal probability chances for precipitation across Canada?
There is a probability of more than 40% for above normal precipitation over the Maritimes, Newfoundland, some parts of Canadian Archipelago and North western BC. Northern Alberta has ~40% probability for below normal precipitation. Otherwise, equal probability chances are expected across Canada for the autumn 2017.

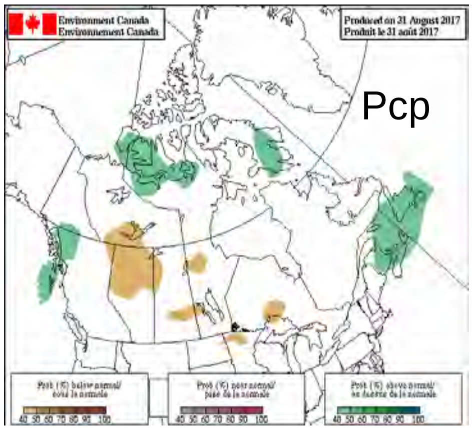


Historical Skill, Tmp



Historical Skill, Pcp



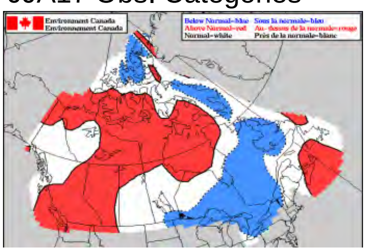


CanSIPS JJA17 forecasted Indices:
Nino3.4 = -0.5 (weak La Nina)
PDO = -0.5 (moderate index)
NAO = 0.1 (weak index)
PNA = will be available soon

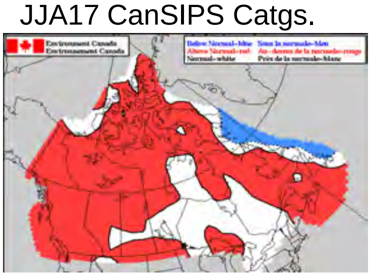
What will influence the next season?

ECCC predicts weak La Nina conditions to develop in SON17 and to persist in the following winter. According to the longer lead seasonal forecast issued by International Research Institute of Columbia University, there is a probability of more than 50% that the neutral ENSO conditions will remain this winter.
Negative **PDO** index will have moderate influence to the coastal BC.
Weakly ***NAO*** is forecasted for SON17, mainly in September, after which skill is low.
PNA index will likely stay positive (until the end of August, according to the CPC). Positive PNA index is historically connected with above average temperatures in the Canadian south west.

JJA17 Obs. Categories

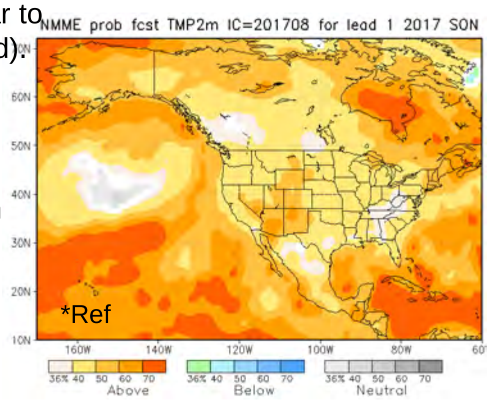


JJA17 CanSIPS Catgs.

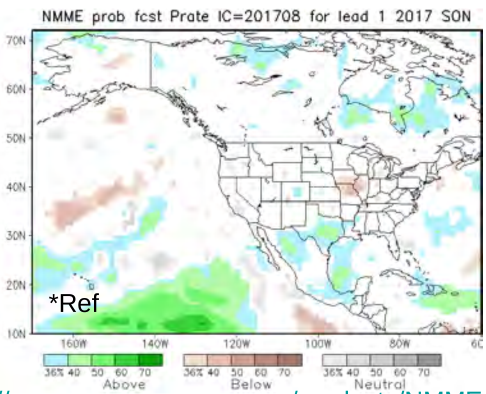


Verification JJA 2017 Percent Correct
Temperature: All stations: 52%; Analysis based: 46%.
Colder than normal summer in southeastern, eastern and southern central Canada is missed.

Seasonal forecast by other centers: Temperature: according to the NMME (North American Multi Model Ensemble) (lead 1 month), probability of above normal temperatures (>60%) is forecasted in eastern Canada and Maritimes. Coastal regions of BC, central BC and southern MT have equal chances probabilities for temperature this autumn. Besides this equal probability chances, NMME forecast is very similar to CanSIPS (15 day lead).



Precipitation:
According to the NMME (on the bottom figure) there is >40% probability of above normal precipitation over northeastern parts of QC and northwestern ON. Similar expectancy of equal probability chances for precipitation is expected in all other parts of Canada.



*Ref: http://www.cpc.ncep.noaa.gov/products/NMME/

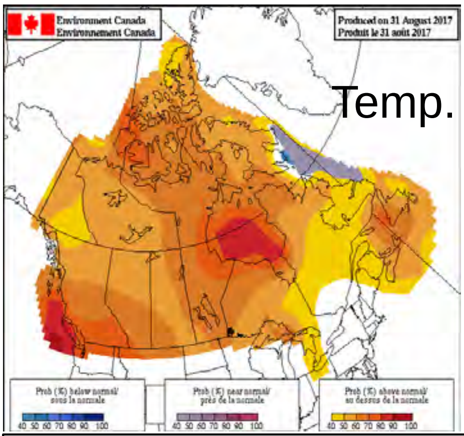
Environment and Climate Change Canada | Environnement et Changement climatique Canada

Prévision saisonnière pour l'automne 2017 (SON) par le système SPISCan, produite le 31 août 2017

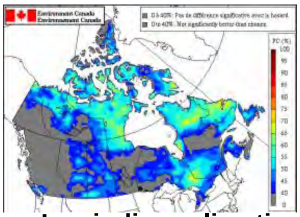
M. Markovic and K. Gauthier

Un automne plus chaud que la normale est anticipé. Des températures au-dessus de la normale sont très probables partout au Canada. Les probabilités les plus élevées (70% et +) sont anticipées, pour les prévisions au-dessus de la normal, dans les régions de la baie d'Hudson, de la côte de la CB et dans l'ouest du Canada. Pour le nord du QC, le nord de l'ON et MT, la région des grands lacs et la côte de la CB, des températures au-dessus de la normale sont attendues avec une probabilité de plus de 60%.

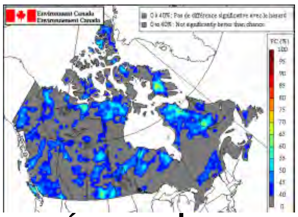
Des probabilités égales de précipitations pour tout le Canada?
Il y a une probabilité plus grande que 40% pour des précipitations au-dessus de la normal, pour les maritimes, Terre-Neuve, quelques parties de l'archipel Canadian ainsi que le nord-ouest de la CB. Le nord de l'Alberta a une probabilité de ~40% de précipitation sous la normale. Par ailleurs, des probabilités égales sont attendues pour tout le reste du Canada pour l'automne 2017

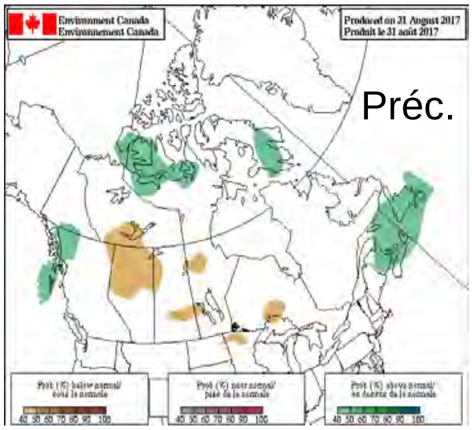


Habilet historique, Temp



Habileté historique, préc.

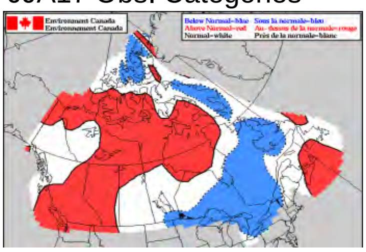




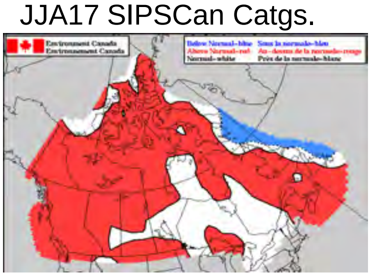
Les indices climatiques prévus par le SIPSCan pour JJA17 :
Nino3.4 = -0.5 (faible La Nina)
PDO = -0.5 (indice modéré)
NAO = 0.1 (indice faible)
PNA = disponible bientôt

Qu'est-ce qui influencera le climat la saison prochaine?
ECCC prévoit le développement d'un faible La Nina pour la saison SON17 et pour l'hiver prochain. Selon la prévision à plus longue échéance du International Research Institute of Columbia University, il y a une probabilité plus grande que 50% que la condition d'ENSO neutre se prolonge cet hiver.
Un indice ***PDO*** négatif aura une influence modérée sur la côte de la CB.
Un faible ***NAO*** *est prévu pour* SON17, principalement en septembre, après quoi l'habileté à prévoir est faible.
L' indice ***PNA*** restera probablement positif (jusqu'à la fin du mois d'août, selon le CPC). Un indice PNA positif est historiquement connecté avec des températures au-dessus de la normal dans le sud-ouest du Canada.

JJA17 Obs. Categories

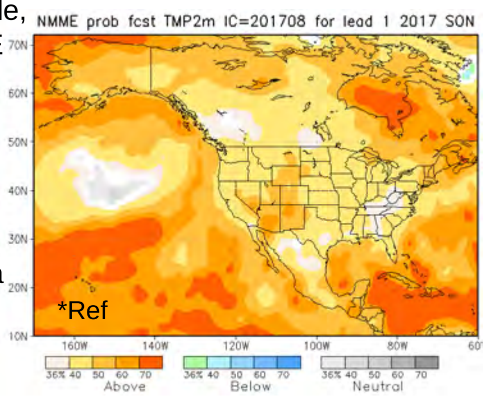


JJA17 SIPSCan Catgs.

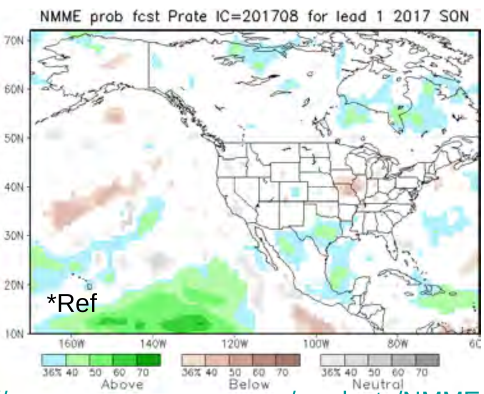


Verification JJA 2017 Pourcentage correct Température: Toutes les stations: 52%; Basé sur analyse: 46%. Température plus froide que la normal, pour l'été, dans le sud-est et le sud centre du Canada est manqué.

Prévisions saisonnières d'autre centre: Temperature: Selon le NMME (North America Multi Model Ensemble) (échéance de 1 mois), une probabilité de température au-dessus de la normal (>60%) est prévue pour l'est du Canada et les Maritimes. Les régions cotières et le centre de la CB, ainsi que le sud du MT ont des probabilités de chances égales pour la température cet automne. Malgré cette probabilitée égale, la prévision du NMME est très similaire à celle de SIPSCan (15 jours d'échéance)



Précipitation:
Selon le NMME (sur la figure du bas), il y a une probabilité >40% de précipitations au-dessus de la normal pour le nord du QC et le nord-ouest de l'ON. Des probabilités de chances égales de précipitation sont attendues sur le reste du Canada.



*Ref: http://www.cpc.ncep.noaa.gov/products/NMME/

News & Events: 51st Annual CMOS Congress

Highlights from the 51st Annual CMOS Congress, June 2017

The 51st Annual CMOS Congress was held June 4th to 8th in downtown Toronto at the Hilton. With over 575 registered participants, 60+ scientific sessions, 15 industry exhibitors, and an assortment of student events and social activities, the Congress was buzzing with activity right from the start.

Pictured at the opening ceremonies are (L to R): Ron Bianchi, LAC chair; Hon. Glen Murray, Minister for Ontario Environment and Climate Change; Ms. Bernadette Jordan, DFO; Prof. Roger Wakimoto, AMS President; Mr. Martin Taillefer, then CMOS President.

For all of those who attended the opening ceremonies on June 5th, there were moments that will not soon be forgotten. With supportive and inspiring talks from CMOS Past-President Mr. Martin Taillefer, Ms. Bernadette Jordan from the Department of Fisheries and Ocean, Minister for Ontario Environment and Climate Change the Honorable Glen Murray, and President of the American Meteorological Society Prof. Roger Wakimoto, the audience were paying attention. Minister Murray, in his usual passionate style, delivered a powerful message to the CMOS scientific community, summing up the state of the warming planet and calling out what he views as the unrealistic goals of the Paris Agreement, given the warming trends that are projected and the shortfall in political and societal response. He challenged us all to get out in to the community to share the science and spread the message of the urgency of climate action, and to get actively involved in politics so as to put in place the structures and policies that are needed now to avoid irreversible and catastrophic changes.

This message of the need for action was echoed by other keynote presenters, including the Environmental Commissioner of Ontario Dr. Dianne Saxe, who finished her talk by saying that although it is too late to avoid large and fundamental changes to our environment, it is not too late to take action. Her three-point action plan included aiming to reduce your carbon footprint by 5% per year, getting ready to adapt to the changes that we are going to see, and speaking up about what you know and what we all need to do to start living more sustainably. For anyone that wants to incorporate this plan in to their lives, and who lives in the Toronto area, then Minister Murray's Carbon footprint calculator is a good place to start.

With scientific sessions looking at everything from the mental health impacts of climate change to cloud microphysics and radiative effects to the human and environmental impacts of melting Arctic sea ice, this year's theme – "Future Earth" – was a topic that ran central throughout. There were 310 scientific oral presentations and 135 poster presentations given over the course of the congress, with abstracts still available through the CMOS Congress app. Although there is not a prize awarded for best talk, three different poster prizes were awarded. Recipient of the Campbell Scientific Poster Prize in Meteorology was Ellen Gute, the ASL Environmental Sciences Poster Prize was awarded to Matthieu Gavelle, and the CMOS Best Poster Prize in Other Disciplines went to Clint Seinen. Congratulations all.

Campbell Scientific show their enthusiasm and support for the CMOS Congress. Pictured here, Campbell Scientific rep Trevor Robertson gives Laura Blazejewski a bit of a break from being on her feet all day!

CMOS Executive Director Gordon Griffith (on left), and Incoming President Wayne Richardson, were all smiles at the CMOS booth.

News & Events: 51st Annual CMOS Congress

Events for Scientists, Educators, and the General Public at the CMOS Congress

The GOES-R workshop on June 4th, which was attended by over twenty individuals from government, academia and the private sectors, was a source of optimism for the ability of science to support us all now, and in to the future. This workshop mapped out the future of geostationary weather satellites that will support more accurate forecasts, real-time mapping of lightning activity, and improved monitoring of solar activity. The Teacher's Day event on June 6th was also filled with hopefulness, as educators from high schools, universities, camps, school boards, the Ministry of Education and various institutes gathered to network, learn hands-on demonstrations, and share resources. Topics included how meteorology is used to design buildings now and in the climate-changed future, how the oceans are being used a garbage dump, and how to spot "fake weather news".

The public lecture by Dr. Francis Zwiers on the evening of June 6th looked at various aspects of climate change disasters, and how the public narrative is sometimes ahead of some of the science. Dr. Zwiers' expertise is in the application of statistical methods to the analysis of observed and simulated climate variability and change. From this perspective he offered his summary that there is a high degree of confidence that temperature extremes are related to anthropogenic climate change, but much less confidence for the relationship between climate change and the frequency of weather-related disasters such as storms, floods and droughts. He did allude to emerging research that suggests that some very warm and humid parts of the planet may become uninhabitable with the continued warming of the planet.

Celebrations and CMOS Awards

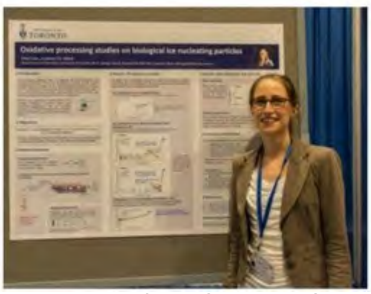
At the congress banquet on June 7th the annual CMOS awards were presented. Award recipients were nominated by their peers for prizes that date back as far as the Society's formation in 1967. This year's recipients included Patrick Cummins and Diane Masson of Fisheries and Oceans Canada who were jointly awarded the President's Prize for their 2014 paper "Climatic variability and trends in the surface waters of coastal British Columbia" published in Progress in Oceanography; and Paul-André Bolduc, previous editor of the CMOS Bulletin, who was awarded the Neil J. Campbell Medal for exceptional volunteer service. The occasion was also the opportunity for the Society to announce the winners of its scholarships valued at $10,000 and of the all-expenses paid two-week Teacher Summer Workshops in atmospheric science and oceanography open to all elementary and high school teachers in Canada. The names of all the recipients can be found on the awards page of the main CMOS website.

The awards were certainly one highlight of the Congress banquet, but the other would have to be the remarkable illusionist, Yan Markson, who entertained the group after the meal. With trick after trick he stunned a room full of scientists in to silence – not an easy task!

Congress photographer Dan Weaver pulled off his own remarkable trick in capturing 244 CMOS members in a group photo in Nathan Phillips Square in Toronto. CMOS archivist Bob Jones has been working hard to ID everyone in the photo, which can be found at on the CMOS website along with all of the other congress photos. A selection of photographic highlights can be viewed on the CMOS flickr page.

Many thanks to all of the congress sponsors and exhibitors for the fantastic support. These include: gold sponsors Campbell Scientific and The Weather Network; silver sponsors Environment and Climate Change Canada and CatIQ; bronze sponsors Zephyr North and RBR; and the many other exhibitors including ATS Services Ltd, Candac, COMET, Hoskin Scientific Ltd, Info-Electronics Systems, MetOcean Telematics, ROMOR Ocean Solutions, ROPOS Canadian Scientific Submersible Facility, Selex ES GmbH, Taylor Francis, and Vaisala.

Finally, a big hats off to the 51st Congress Local Arrangements Committee (LAC) Chair Ron Bianchi and his team of 37 volunteers for running such a smooth show. Taking care of everything from securing accommodation for hundreds of people to rounding out the corners of the banquet menus, the team really did an exceptional job at making the 51st CMOS Congress one to remember. With a strong LAC already working hard for next year's congress, the 52nd CMOS Congress to be held from June 10th to 14th 2018, in Halifax, should not be missed.




L to R: 51st CMOS Congress group photo in Toronto; winner of the Campbell Scientific poster prize in Meteorology Ellen Gute; CMOS friends and colleagues at the banquet and awards ceremony.

News & Events: 51st Annual CMOS Congress

50 Years Later, CMOS Membership is Captured on Camera

The photo on the left was taken at the very first annual congress of the Canadian Meteorological Society in 1967. Fifty years later, membership has most certainly grown, and the demographics of the Society have most certainly changed.

To celebrate both the occasion of our 50th birthday, and the much improved gender and racial diversity of the Society, we managed to get 244 Toronto Congress attendees for a group shot in Nathan Phillips Square.

Thank-you to all who made the effort to make this happen!

CMOS' Archivist, Bob Jones, has been working hard to ID everyone in the photo. You can find this work by scrolling to the very bottom of the 2017 Congress Photos page (http://cmosarchives.ca/CongressPhotos/collage2017congress.html). If you are in the group photo please do let us know if we haven't yet managed to match your name to your face - there are 98 people still unidentified - so you can go down in CMOS history too!

News & Events: 51st Annual CMOS Congress

Thank you to all of the 51st CMOS Congress sponsors and exhibitors!

Gold Sponsors

CAMPBELL SCIENTIFIC — WHEN MEASUREMENTS MATTER

Météo Média — The Weather Network

Silver Sponsors

CatIQ™ — Catastrophe Indices and Quantification Inc.

Environment and Climate Change Canada / Environnement et Changement climatique Canada

Other Sponsors

Zephyr North

RBR

Exhibitors

HOSKIN SCIENTIFIC

ROPOS — CANADIAN SCIENTIFIC SUBMERSIBLE FACILITY

ROMOR — Engage ROMOR. Deploy with confidence.

UCAR COMMUNITY PROGRAMS — COMET

Info-Electronics Systems Inc. / Systèmes Info-Électroniques Inc. — ISO-9001

Selex ES — A Finmeccanica Company

VAISALA

CANDAC — Canadian Network for the Detection of Atmospheric Change

ATS CANADA

metOcean™ telematics

Taylor & Francis — Taylor & Francis Group

Other CMOS News

Announcement: Arctic Change 2017 - Call for Abstracts

Building on the success of its previous Annual Scientific Meetings, the ArcticNet Network of Centres of Excellence and its national and international partners invite the international Arctic research community to the International Arctic Change 2017 Conference at the Quebec City Convention Centre, Québec, Canada from December 11 – 15, 2017.

Arctic Change 2017 will bring together leading Arctic researchers, graduate students, Northern community representatives, government and industry partners and stakeholders from all fields. During the week, the world's foremost Arctic scientists will discuss the emerging global challenges and opportunities arising from climate change and modernization in the circum-Arctic. With over 1500 participants expected to attend, Arctic Change 2017 will be one of the largest trans-sectoral international Arctic research conferences ever held in Canada.

The International Arctic Change 2017 Conference will run over five days beginning with Student Day on Monday, 11 December and ending on Friday, 15 December at 12:00. Please refer to the Arctic Change 2017 website for further information, but note that the deadline to submit abstracts is Friday, September 22, 2017.

ArcticNET session for CMOS Arctic SIG members

One session of interest to the CMOS Arctic SIG reader is the session on: Advancing Statistically and Dynamically Accurate Descriptions of the Physical and Biogeochemical State of the Ocean.

This session will highlight the work of major Canadian initiatives that are describing the physical and biogeochemical state of the ocean. The initiatives highlighted in the session will include the Canadian government led work on CONCEPTS (Canadian Operational Network on Coupled Environmental Prediction Systems); the Dalhousie University led Network of Centres of Excellence MEOPAR (Marine Environmental Observation, Prediction and Response); the international Green Edge project; and, others. Significant work has been undertaken by these initiatives which are complementary and together cross the spectrum of observations, modelling, predictions, and statistical and dynamic representations that can most accurately describe conditions of ice, physical and biogeochemical states of oceans. This session will link observations to models and will highlight the benefits in sharing observations and needs regarding observing system design. Efforts to describe the physical and biogeochemical state of Canada's north are particularly important in support of the ongoing Year of Polar Prediction (YOPP). The session will highlight the need for meaningful user engagement and stakeholder uptake of information with the demonstration of the Ocean Navigator as one such mechanism.

For further information: Please contact any of the co-chairs for this session: Dany Dumont, Université du Québec à Rimouski (dany_dumont@uqar.ca); Fraser Davidson, Fisheries and Oceans Canada (fraser.davidson@dfo-mpo.gc.ca) and Laurent Memery, Laboratoire des sciences de l'environement marin, CNRS France (Laurent.Memery@univ-brest.fr).

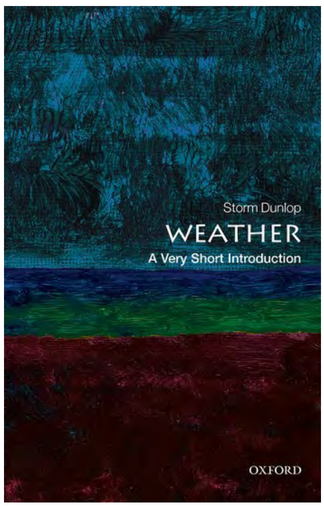
Books in search of a Reviewer*:

(2016-2) *Heliophysics: Active Stars, their Astrospheres, and Impacts on Planetary Environments*, 2016.
Edited by Carolus J. Schrijver, Frances Bagenal, and Jan J. Sojka, Cambridge University Press, ISBN 978-1-107-09047-7, Hardback, 406 pages, $68.95

(2017-1) *Weather: A Very Short Introduction*, 2017. By Storm Dunlop, Oxford University Press, ISBN 978-0-19-957131-4, Paperback, 152 pages, $11.95

(2017-3) *Eustasy, High-Frequency Sea-Level Cycles and Habitat Heterogeneity*, 2017. By Mu Ramkumar and David Menier, Elsevier Inc, ISBN 978-0-12-812720-9, Paperback, 102 pages, $60 US

You review it, yours to keep!



Other CMOS News

CMOS Researchers Speak Up to Fight for CCAR

Paul Kushner, Jim Drummond, René Laprise, Kim Strong, and other CMOS researchers have been making their voices heard to support continued funding for the Climate Change and Atmospheric Research (CCAR) program. Most recently they contributed to articles appearing in Physics Today and the National Observer.

"There is an unfortunate perception that no more science is needed in climate research," says Paul Kushner, a University of Toronto physicist and principal investigator of a CCAR project on observations and predictions of sea ice and snow. The Canadian government is prioritizing mitigation and clean technologies, he says. (Excerpt from Physics Today, http://dx.doi.org/10.1063/PT.3.3689)

Ottawa has not yet announced that funding for the CCAR program, which supports the Polar Environment Atmospheric Research Laboratory (PEARL) and six other projects, will be renewed after it runs out at the end of the year .

INVESTING IN CANADA's FUTURE: Strengthening the Foundations of Canadian Research

If you haven't already checked it out, do have a look at the report put together by the Advisory Panel for the Review of Federal Support for Fundamental Science, which presents a plan to strengthen Canada's research ecosystem. The report *"Investing in Canada's Future: Strengthening the Foundations of Canadian Research"* was prepared by an independent, expert advisory panel and was commissioned by the Minister of Science, Kirsty Duncan. In 2016, the Canadian Consortium for Research (CCR), in partnership with CMOS, made a submission to the panel that highlighted key issues affecting Canadian research and researchers.

The full report and executive summary can be found on http://www.sciencereview.ca/eic/site/059.nsf/eng/home

GET SCIENCE RIGHT: new campaign aimed to promote the importance of investment in science for all of Canadian society.

http://science.caut.ca/

Want to hear more from your favourite 2017 CMOS Congress plenary session presenters?

Short video interviews with all of the plenary session speakers, conducted and put together by Dominque Paquin, are now available on CMOS' new YouTube channel.

Change the World: Geoff Strong

As part of the "Change the World with Guy Dauncey" series, CMOS past-president, author, and atmospheric scientist Geoff Strong was interviewed on the subject of changing climate conditions around the world. His interview can be found on youtube at http://tinyurl.com/GeoffCMOS

Change the World is one of several Community Access productions developed in partnership with Shaw TV Nanaimo.

Council / Conseil d'administration

President / Président
Wayne Richardson
Tel.: 613-729-6757; Cel.: 613-851-7071; E-mail/Courriel: president@cmos.ca

Vice-President / Vice-président
Paul Kushner
Department of Physics, University of Toronto, Toronto, ON
Tel.: 416-946-3683; E-mail/Courriel: vice-president@cmos.ca

Past-President / Président Sortant
Martin Taillefer
Maritime Way Scientific Ltd., Ottawa, ON
Tel.: 613-841-0505; Cel.: 613-252-8311; E-mail/Courriel: past-president@cmos.ca

Treasurer / Trésorier
Michael Crowe
Environment and Climate Change Canada, Gatineau, QC
Tel.: 819-938-4379; E-mail/Courriel: treasurer@cmos.ca

Corresponding Secretary / Secrétaire-correspondante
Fiona Robertson
E-mail/Courriel: corsec@cmos.ca

Recording Secretary / Secrétaire d'assemblée
Marie-France Gauthier
Tél.: 613-668-3927; E-mail/Courriel: recsec@cmos.ca

Councillors-at-large / Conseillers
1) Patrick Roussel
Metocean Services, Dartmouth, NS
Tel.: 902-468-2848; E-mail/Courriel: patrick.roussel@amecfw.com

2) Robert Sica
University of Western Ontario, London, ON
Tel.: 519-661-3521; E-mail/Courriel: bobsica@purplecrowlidar.ca

3) Nadja Steiner
Department of Fisheries and Oceans, CCCma, Environment Canada
E-mail/Courriel: nadja.steiner@canada.ca

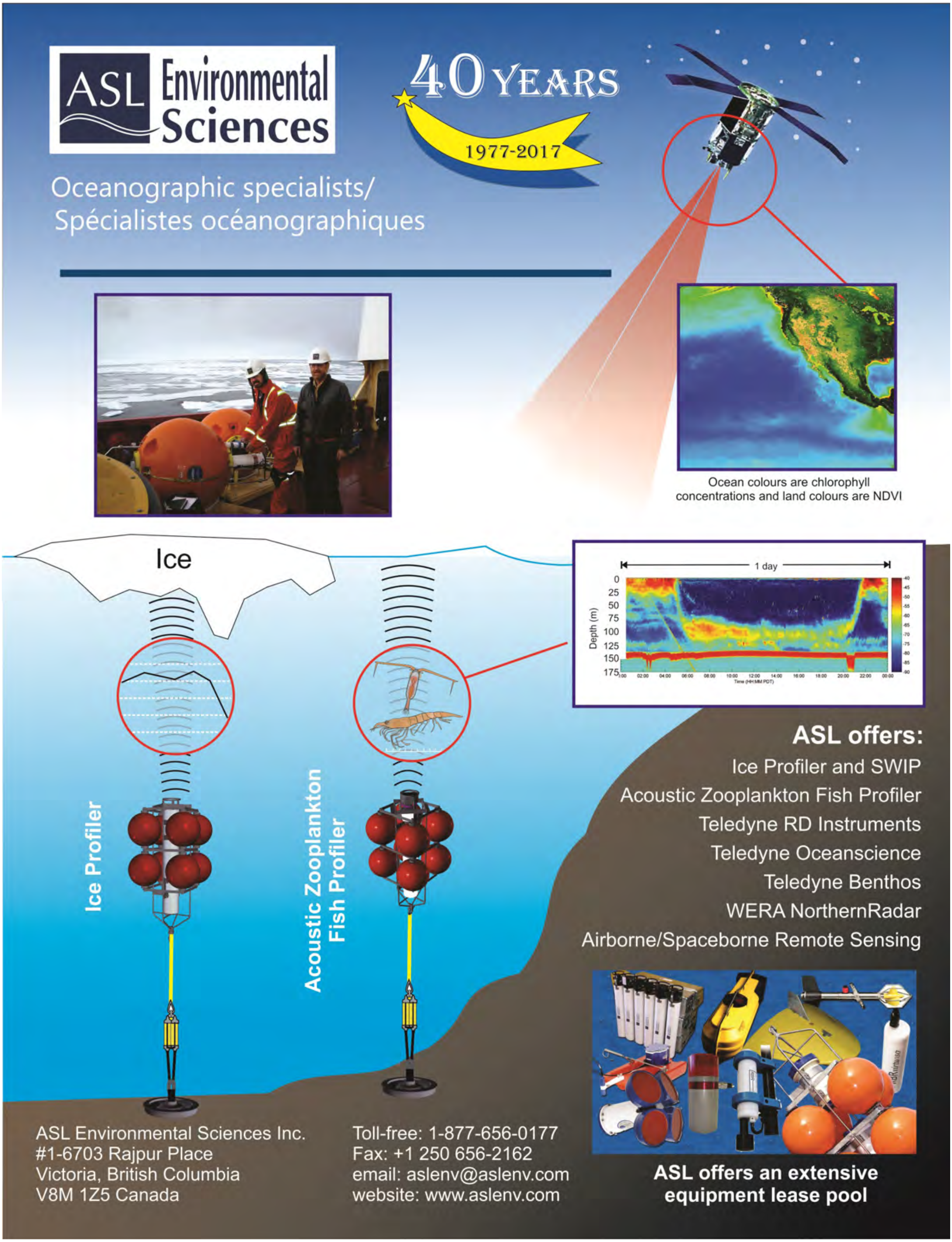
NEWS: CMOS Bulletin SCMO @ bulletin.cmos.ca

The CMOS Bulletin will be moving on-line to http://bulletin.cmos.ca. Please continue to send articles, notes, workshop reports and news items to bulletin@cmos.ca. We will be accepting, reviewing, and publishing content on an on-going basis.

Prochain numéro du CMOS Bulletin SCMO

Le *Bulletin de la SCMO* sera trouvé en ligne à http://bulletin.scmo.ca/. N'hésitez pas à soumettre notes, rapports d'atelier et nouvelles à l'adresse bulletin@scmo.ca. Nous accepterons, réviserons et publierons vos contenus sur une base continue.

Thank you to Bob Jones and Paul-André Bolduc, for their continued editorial assistance and guidance.


ASL Environmental Sciences
40 YEARS
1977-2017
Oceanographic specialists/
Spécialistes océanographiques
Ocean colours are chlorophyll concentrations and land colours are NDVI
Ice
1 day
Depth (m)
0
25
50
75
100
125
150
175
Ice Profiler
Acoustic Zooplankton Fish Profiler
ASL offers:
Ice Profiler and SWIP
Acoustic Zooplankton Fish Profiler
Teledyne RD Instruments
Teledyne Oceanscience
Teledyne Benthos
WERA NorthernRadar
Airborne/Spaceborne Remote Sensing
ASL Environmental Sciences Inc.
#1-6703 Rajpur Place
Victoria, British Columbia
V8M 1Z5 Canada
Toll-free: 1-877-656-0177
Fax: +1 250 656-2162
email: aslenv@aslenv.com
website: www.aslenv.com
ASL offers an extensive equipment lease pool

52nd CMOS Congress | 52e Congrès de la SCMO

2018 HALIFAX

June 10 -14 | du 10 au 14 juin 2018

Halifax Convention Centre

2018 CONGRESS THEME | THÈMATIQUE DU CONGRÈS

Marine and Environmental Risks and Impacts

Risques et Impacts Maritimes et Environnementaux

CMOS SCMO

Canadian Meteorological and Oceanographic Society

La Société Canadienne de Météorologie et d'Océanographie

www.cmos.ca