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La Société canadienne de météorologie et d'océanographie

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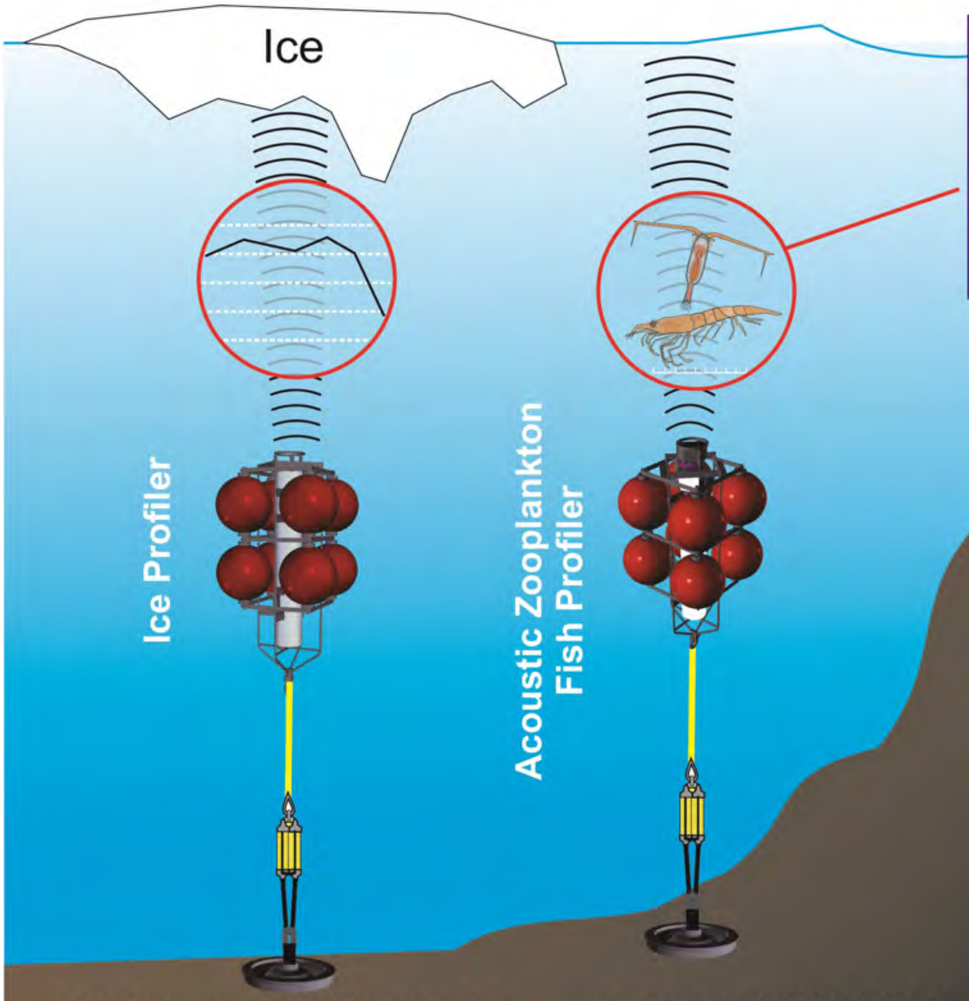
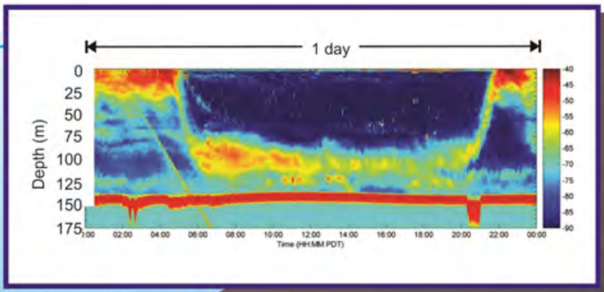
Photo: Christian Haas

Ocean colours are chlorophyll concentrations and land colours are NDVI





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Articles

CMOS Business and News

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CMOS Bulletin SCMO

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

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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

Photo (courtesy of Christian Haas) of a DC3-T Basler BT67 aircraft carrying out electromagnetic (EM) ice thickness surveys in the Arctic Ocean between Canada and the North Pole. The EM sensor ("EM Bird") can be seen 15 m above the ice, tethered 80 m below the aircraft. The photo was taken from an ice floe at a latitude of 83.5°N north of Ellesmere Island, in April 2011, during York University's and the European Space Agency's CryoSat validation campaign (CryoVEx). The ice floe was visited with a ski-equipped Twin Otter. On the ice, various in-situ measurements of ice and snow properties were carried out, while three aircraft equipped with ice thickness sensors, scanning lidars, and specialized radar altimeters flew overhead, and also aligned with a CryoSat overpass. Such co-located measurements are required to address the various uncertainties of CryoSat ice thickness retrievals related to variable radar snow penetration and difficult freeboard to ice thickness conversion (see article on page 11). Airborne EM ice thickness surveys are also carried out annually to observe regional and temporal ice thickness variations in the Canadian Arctic.

Results of CryoVEx and other CryoSat research will be presented at this year's North-American CryoSat Science Meeting in Banff, Alberta, from March 20-24, 2017.
http://www.cryosat2017.org/

◆

Photo (courtoisie de Christian Haas) d'un avion DC3-T Basler BT67 exécutant un levé de l'épaisseur de la glace par sondage électromagnétique, dans l'océan Arctique entre le Canada et le pôle Nord. Le capteur électromagnétique (*EM Bird* ou « oiseau ») se situe à 15 m au-dessus de la glace, au bout d'un câble de 80 m. La photo a été prise à partir d'un floe, à 83,5° de latitude nord, au nord de l'île Ellesmere, en avril 2011, durant la campagne de validation de CryoSat (CryoVEx), qu'avaient entreprise l'Université York et l'Agence spatiale européenne. Un Twin Otter équipé de ski a atterri sur le floe. Diverses propriétés de la glace et de la neige y ont été mesurées *in situ*, tandis que trois aéronefs embarquant des capteurs d'épaisseur de la glace, des lidars à balayage et des radioaltimètres spécialisés ont passé au-dessus du floe, et ce, en même temps que le satellite CryoSat. Le recoupement de ces mesures sert à déterminer les diverses incertitudes des relevés d'épaisseur de glace venant de CryoSat, en ce qui a trait à la pénétration radar variable de la neige, et à la conversion difficile entre la hauteur du franc-bord et l'épaisseur de la glace (voir l'article à la page 11). Des levés électromagnétiques de l'épaisseur de la glace par des instruments aéroportés sont aussi réalisés annuellement, afin d'observer les variations régionales et temporelles de l'épaisseur de la glace dans l'Arctique canadien.

Les résultats de CryoVEx et d'autres études portant sur CryoSat seront présentés au congrès North-American CryoSat Science, à Banff (Alberta), du 20 au 24 mars 2017. http://www.cryosat2017.org/

Christian Haas, enjoying the weather during a 5-day snowmobile journey from Resolute Bay to Grise Fjord, May 11, 2012. The selfie was taken after an overnight ride through dense fog, just as the sun rose and burned off the mist.

Je profite des conditions météo, le 11 mai 2012, lors d'un voyage de cinq jours en motoneige de Resolute à Grise Fiord. L'égoportrait a été pris après un trajet de nuit dans le brouillard, tandis que le soleil se levait et dissipait la brume.

Words from the President

Dear Friends and Colleagues – Happy New Year!

In 1960 the Canadian Government established a new committee to coordinate and direct its work in oceanography, and to represent the government in the field of oceanographic research. Thus the Canadian Committee on Oceanography (CCO) was stood up. At the time, the Federal Agencies interested in Oceanography were the Royal Canadian Navy, the Fisheries Research board, the Dept. of Mines and Technical Surveys, the National Research Council, and the Meteorological Branch and the Marine Services of the Dept. of Transport. The CCO started off with a very pro-active mandate by representing the government internationally at the Special Conference on Oceanographic Research (SCOR) and on the NATO Scientific Committee on Oceanographic Research. Back in Canada, the CCO spearheaded coordination of federal activities with universities - and a cornerstone of the CCO was the establishment of a $3-million dollar institute that would be named the Bedford Institute of Oceanography (BIO). This was followed by the support of the construction of new oceanographic vessel, *C.G.S. Hudson* commissioned in 1963.

Yet, a hallmark of the Canadian Committee on Oceanography was its sub-committees, namely the Pacific, Atlantic & Arctic. This is where the work of the CCO got to the grass roots of Canadian oceanography and drove its mandate at the regional and local levels. Unfortunately, by the late 70's and early 80's the CCO fizzled away without much fanfare. Interestingly enough, the Pacific Sub-Committee on Oceanography (PSCO) carried on for many more years – helping the Pacific regions with CCG ship-scheduling and collaboration with different ocean groups. Near the later stages of the 1990's the sub-committee lost its purpose and, as last sitting PSCO Secretary and the Navy's Pacific Fleet Oceanographer, I had to close doors of the PSCO in 2000.

Nonetheless, it was my experiences with the remnant of the CCO and PSCO that motivated my support and growth of the Special Interest Groups (SIG) at CMOS. While the SIGs do not have the same clout and purpose as the CCO's Sub-Committee in its day, the parallels are uncanny. The challenge is to drive these SIGs to have a greater reach and pro-active arm for our Society. Over the past 5 years two new SIGs have been stood up and are gaining traction with our community: the Arctic & Aviation SIGs. Helen Joseph, Chair of the Arctic SIG, has been very active in using the Congresses to promote and advance the growing importance of Northern and Arctic issues. The Arctic SIG will be convening two scientific sessions at this year's Congress and she is working hard to ensure a strong presence of Arctic science: (Session 1) - Strategies for Arctic Ocean Observing; and (Session 2) - The Year of Polar Prediction. Steve Ricketts, Chair of the Aviation SIG, has built up well the SIG web site and Facebook presence. He has been raising the level of awareness about the Aviation SIG and its purpose within CMOS. Steve has initiated several and frequent conversations about aviation weather angles with Aviation SIG members and others around the world.

David Fissel (Past President of CMOS) once stated that it would be great if participants at the Congresses would be motivated to attend due to the SIGs. In turn, Steve reflected that the SIGs recent efforts have raised the visibility of CMOS, and we are starting to attract new members.

Ultimately, I would like to see many more Special Interest Groups. This would promote and advance Met & Ocean sciences to the Canadian community, and place CMOS members in a more structured and visible position to provide ever needed guidance and support on issues of national and global importance. I am always looking to grow the SIG cadre. The Arctic and Aviation groups are a great start – but perhaps in future months and years we could see Atlantic, Pacific, Earth Observation (CSA), and Climate Change SIGs to round out our CMOS expertise and community.

Fair winds and a following Sea,

M.L. Taillefer, President

Allocution du président

Chers amis et collègues, bonne année!

En 1960, le gouvernement canadien a créé un nouveau comité, afin de coordonner et d'orienter ses travaux en océanographie, et de représenter le gouvernement dans le domaine de la recherche océanographique. Ainsi est né le Comité canadien d'océanographie (CCO). À l'époque, les organismes fédéraux que l'océanographie concernait comprenaient la Marine royale canadienne, le Conseil de recherches sur les pêcheries du Canada, le ministère des Mines et des Relevés Techniques, le Conseil national de recherches du Canada, et les directions de la météorologie et des services maritimes du ministère des Transports. Le CCO a inauguré son mandat de façon très proactive en représentant internationalement le gouvernement au congrès spécial sur la recherche océanographique (SCOR) et au sein du Comité scientifique pour les recherches océaniques relevant de l'OTAN. Au pays, le CCO a coordonné les activités fédérales avec les universités. Une de ses grandes réalisations a été la création d'un institut de trois millions de dollars qui allait porter le nom d'Institut océanographique de Bedford (IOB). Puis a suivi le financement de la construction d'un nouveau navire de recherche océanographique, le *NGCC Hudson*, mis en service en 1963.

Mais la marque particulière du Comité canadien d'océanographie était ses sous-comités, notamment ceux du Pacifique, de l'Atlantique et de l'Arctique. C'est ici que les travaux du CCO touchaient au cœur de l'océanographie canadienne et étendaient son mandat aux échelons régional et local. Malheureusement, fin 1970 et début 1980, le CCO s'est éteint sans tambour ni trompette. Étonnamment, le sous-comité pour l'océanographie du Pacifique (PSCO) lui a survécu. Pendant plusieurs années, il a aidé les régions du Pacifique à organiser les horaires des navires de la GCC et a collaboré avec différents groupes liés à l'océan. À la fin des années 1990, le sous-comité avait perdu sa pertinence. En tant que dernier secrétaire actif du PSCO et océanographe de la flotte du Pacifique de la marine, j'ai dû mettre la clef dans la porte du PSCO en 2000.

Néanmoins, cette expérience acquise au sein de ce qui restait du CCO et du PSCO a motivé mon soutien des groupes d'intérêts spéciaux et de leur croissance au sein de la SCMO. Bien que ces groupes ne possèdent pas le même panache ni les mêmes objectifs que les sous-comités du CCO jadis, il existe tout de même certains parallèles. Il faut donc s'efforcer de mettre ces groupes d'intérêts à l'avant-plan, d'élargir leur portée et d'en faire des organes proactifs de notre Société. Au cours des cinq dernières années, deux nouveaux groupes d'intérêts spéciaux ont vu le jour et gagnent du terrain parmi notre communauté : le groupe pour l'Arctique et celui pour l'aviation. Helen Joseph, la présidente du groupe pour l'Arctique, a entrepris d'utiliser les congrès afin de souligner l'importance croissante des enjeux liés au Nord et à l'Arctique. Le Groupe pour l'Arctique organisera deux séances scientifiques au prochain congrès et Helen travaille d'arrache-pied pour garantir une forte contribution du domaine des sciences de l'Arctique (séance 1 : Stratégies appliquées à l'observation de l'océan Arctique; séance 2 : L'Année de la prévision polaire). Steve Ricketts, président du Groupe d'intérêts spéciaux pour l'aviation, a renforcé la présence du Groupe sur le Web et Facebook. Il s'efforce d'augmenter au sein de la SCMO la visibilité et la pertinence du Groupe pour l'aviation. Steve a amorcé des discussions diverses et fréquentes sur différentes facettes de la météorologie aéronautique, et ce, avec les membres du Groupe pour l'aviation et nombre de personnes du monde entier.

David Fissel (ancien président de la SCMO) a affirmé jadis qu'il serait bien que les groupes d'intérêts spéciaux puissent motiver les participants à s'inscrire aux congrès. En outre, Steve a mentionné que les activités récentes des groupes d'intérêts ont augmenté la visibilité de la SCMO et commencent ainsi à attirer de nouveaux membres.

À terme, je souhaite la création de plusieurs autres groupes d'intérêts spéciaux. Ces groupes pourraient ainsi faire progresser les sciences météorologiques et océanographiques, et les promouvoir auprès de la société canadienne. Ils donneraient aux membres de la SCMO un environnement structuré et visible leur permettant de fournir les conseils et le soutien nécessaires relativement aux enjeux d'importance nationale et mondiale. Je cherche constamment à élargir le cadre des groupes d'intérêts spéciaux. Les groupes pour l'Arctique et pour l'aviation représentent un bon départ. Mais au cours des prochains mois ou des prochaines années, peut-être verrons-nous des groupes pour l'Atlantique, le Pacifique, l'observation de la Terre (ASC) et les changements climatiques, afin d'encadrer l'expertise de nos membres et de notre communauté.

Bon vent, bonne mer!

M. L. Taillefer, Président

The Southeasterly Windstorm Trackway of Southwest British Columbia

Wolf Read, School of Resource and Environmental Management, Simon Fraser University

Introduction

High windstorms are an infrequent but endemic feature of the southwest British Columbia (BC) climate (Mass and Dotson 2010, Read 2015). During these storms, 2-minute wind speeds in the major population centres, including Metro Vancouver and Victoria, typically reach 65-80 km/h with gusts of 90-110 km/h. Such wind speeds readily break branches and topple trees, with the potential for widespread windthrow given other factors such as soil conditions, topographic exposure and phenological state. The tree debris, a force amplifier, can fall through utility lines, across roads and onto railroad tracks, disrupting key lifelines. Windthrow also damages or destroys vehicles and homes. During many windstorms, fatalities occur, often from trees or branches striking people, but also from other impacts including electrocution from downed power lines and asphyxiation due to improper portable generator use during blackouts (Gulati et al. 2009, Read 2008, Read and Reed 2013). The rare windstorm can bring 2-minute winds in excess of 90 km/h with gusts of 125-140 km/h, speeds that historically have caused catastrophic damage to the region.

Definitions and Data Sources

A climatology of southwest BC windstorms has been developed first by using the hourly and special observations, obtained from Environment Canada (EC), for three key long-term stations in the southwest BC interior: Victoria, Vancouver and Abbotsford. The region encompassed by these stations is here referred to as the southwest BC interior. For the time period 1994-2016, roughly the era of automated wind reports, independent windstorms were isolated from the record using minimum cutoffs of ≥ 63 km/h (34 knots) for peak 2-minute wind and ≥ 89 km/h (48 knots) for peak 3- or 5-second gust.

In almost all cases, high windstorms in the interior of southwest BC were triggered by the close passage of an extratropical cyclone. The tracks for the associated low-pressure centers have been determined using surface analysis maps obtained from Environment Canada, the United States (US) Weather Prediction Center and National Centers for Environmental Information (NCEI). In some cases, additional information including satellite photos and surface data, obtained from the US National Weather Service and the NCEI, were analyzed to help refine tracks. In addition to the storm center position, other variables were also determined, including central pressure magnitude and tendency, and storm forward speed and bearing.

The Southeaster Trackway

When considering peak wind direction, most southwest BC windstorms fall into two broad categories: westerly with peak winds from 260º to 320º at Vancouver, and southeasterly with peak winds from 100º to 160º, but sometimes 160 º to 200º at Abbotsford and Victoria. Of these two categories, southeasters have historically been the most destructive. The Columbus Day Storm ("Typhoon Freda") of 12 October 1962, an event that established most of the all-time highest gust speeds on record in the region, had southeasterly peak winds (Lynott and Cramer 1966, Read 2015). The catastrophic 21 October 1934 windstorm produced intense southeast winds as it approached the region, followed by an equal-magnitude westerly gale as the low tracked into the mainland (Read 2015). On average, southeasters cause about 1.5 times more power outages than westerly windstorms (Read 2016).

A total of 65 independent windstorms occurred during the period 1994-2016, each following a unique path over a broad swath of the Northeast Pacific (Figure 1). Some order can be discerned from the apparent chaos. Southeasters have a strong tendency for recurvature, generally resulting in more meridional tracks than westerly windstorms. Likely, there are multiple reasons for the recurvature. One contributor is that many southeasterly windstorms develop in the base of sharp U-shaped upper-level trough with an axis centered at approximately 135º to 145ºW (Mass and Dotson 2010, Read 2015). In this situation, the upper steering currents are favorable for tracks with a north-northeast to north direction right off of the West Coast of North America.

Southeasterly windstorm tracks appear to cluster strongly just off of the Oregon, Washington and BC coasts with many landfalls on Vancouver Island, suggesting that a close proximity to the southwest BC interior results in favorable conditions for high winds. The cluster paints a mean path area for southeasterly windstorms: the Southeaster Trackway (Figure 2). The trackway accentuates the tendency for recurvature as the extratropical cyclones near the Pacific Coast, describing a wave that roughly follows a typical trough-ridge pattern across the Northeast Pacific and western North America that is often present during southeasterly windstorms. The ridge, typically centered over the US Great Basin and extending southwest over California, contributes to high winds by helping support a strong surface pressure gradient on the south side of landfalling extratropical cyclones.

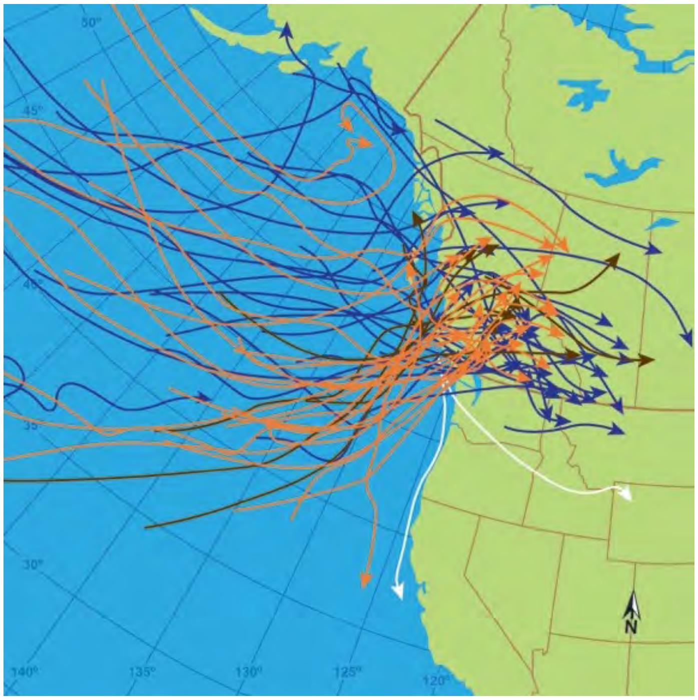

Figure 1: The tracks of all extratropical cyclones that produced peak 2-minute winds of ≥ 63 km/h and or peak 3- to 5-second gust ≥ 89 km/h at either Victoria, Vancouver or Abbotsford for the 23 years 1994-2016 (inclusive). The paths are color coded to indicate peak wind direction: southeasterly windstorms are orange, westerly are blue, southerly and southwesterly are brown, and easterly are white.

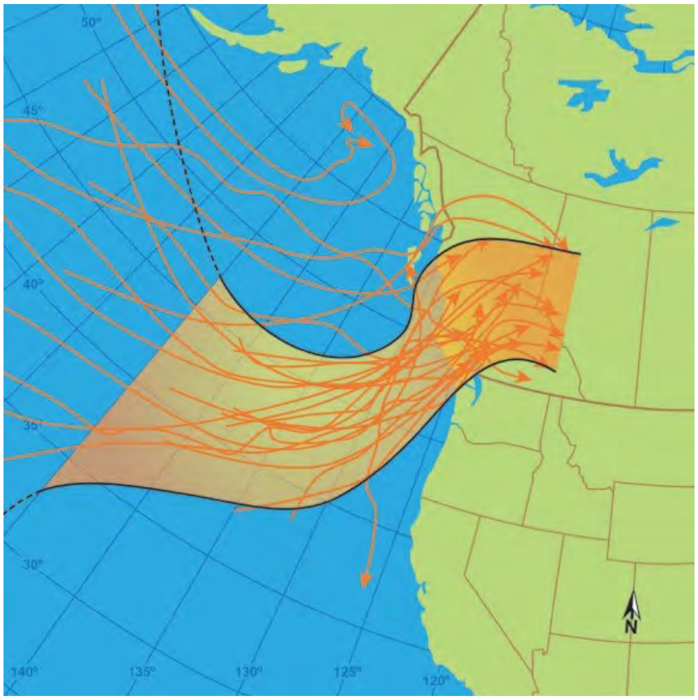

Figure 2: The tracks of all low-pressure centers that triggered southeasterly windstorms in southwest BC from 1994-2016. The region that contains most of the paths is highlighted, forming the Southeaster Trackway.

Within the Southeaster Trackway, four key extratropical cyclone development regions have been defined (Figure 3): a) incipient cyclone, where some storms get their start, often from weak "seed" lows; b) cyclogenesis, a common region of storm initiation; c) peak development, where the storm systems tend to reach their maximum intensity; and d) cyclolysis, where many southeasterly windstorms weaken and are absorbed as they move away from the area of best upper support and encounter the steep, rugged terrain of southwest BC. Not every southeaster goes through each stage of its development cycle within the specified regions. Some may start early, while others start late. The polygons, however, capture the stages for many and serve as a reasonable guide. Examination of central pressures shows a clustering of minimums around 48ºN and 130ºW (Figure 4). This is in the peak development polygon, supporting the placement of the regions.

Figure 3: Key development regions for extratropical cyclones that produce southeasterly high winds in the study region.

Twenty-two independent extratropical cyclones that triggered southeasterly windstorms in the study region moved through the trackway during 1994-2016. When considering the six-hourly (6-h) storm center positions of these storms, there are 190 total datapoints (Figure 5, Table 1). The 6-h position and central pressure data at each of these locations offers a means to estimate average conditions for extratropical cyclones traversing the different developmental regions and also determine a mean storm track for southeasterly windstorms. The average latitude for all of the storm positions in the dataset is 46.1ºN.

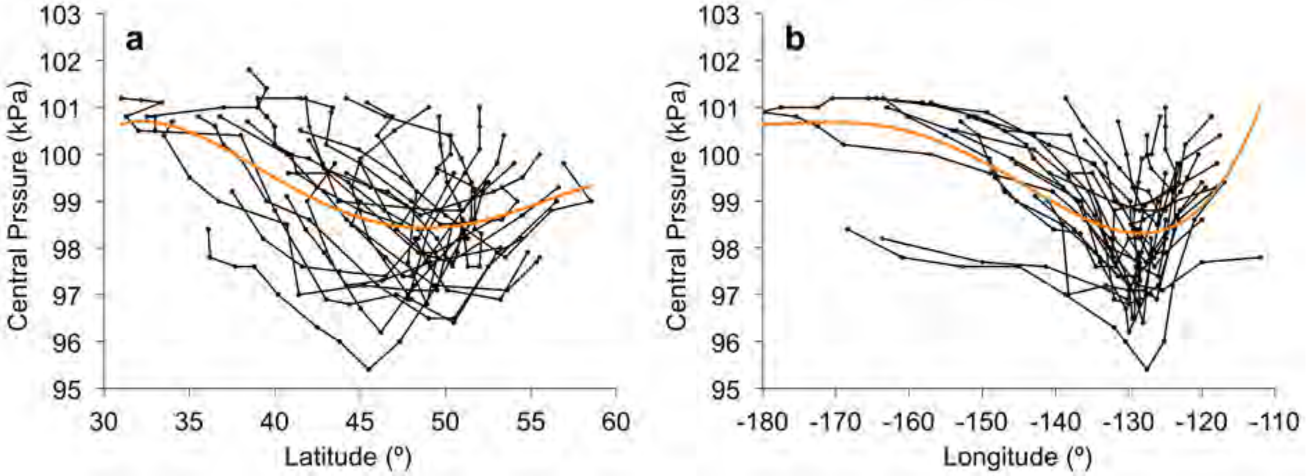

Figure 4: Six-hourly central pressures for high-wind-generating extratropical cyclones that traversed the Southeaster Trackway 1994-2016. Values are plotted against latitude (a) and longitude (b). Included is a 4th-order polynomial fit to the data points (orange line) that is intended simply as a guide.

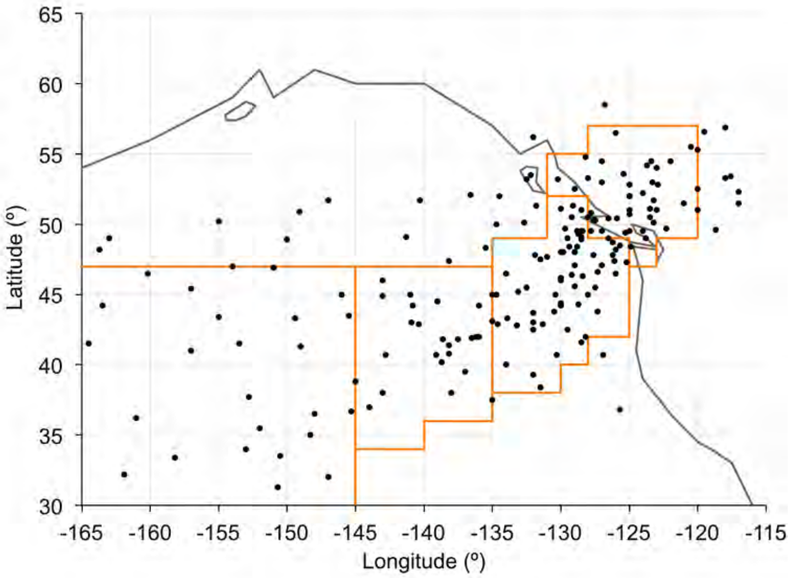

Figure 5: Black dots indicate the six-hourly low-pressure center positions for 22 southeasterly windstorms that tracked within the four development regions (orange lines) during 1994-2016. The Pacific Coast of North America is shown in gray.

Developmental Region	Total Independent Storms	Total 6-h Observations
a	14	53
b	18	28
c	19	64
d	19	45

Table 1: Total number of independent extratropical cyclones that tracked through given developmental regions. Also shown are the total 6-h observations for the same storms.

Summary statistics are based on averaging the observations for each storm in a given development area, thus providing one discrete observation for each storm per region (Table 2). The number of samples per polygon is a relatively low 12-19 after some observations that were deemed outliers were eliminated. Given the limited number of independent storms, confidence in the averages is not high. For example, standard deviations are rather large. Error in the determination of low-pressure center positions and central pressures over the Northeast Pacific, where surface observations can be very widely spaced, also contributes to the uncertainty. A larger storm sample would probably improve confidence in the numbers. However, individual storms follow a wide variety of tracks and undergo marked variation in their development sequence, and any improvement might be marginal at best.

Taking averages at face value, approximate development times can be estimated by dividing the distance between the mean storm positions of two developmental regions by the average of the forward motion speeds for the same regions (Figure 6). The mean path for storms in the Southeaster Trackway tends to roughly follow the 42ºN latitude line up to about 140ºW where recurvature begins, taking 27 hours on average to cover the distance. This is for those storms that started development west of 145ºW. Many extratropical cyclones begin between 145º and 135ºW. This is why *t* = 0 h is placed in the cyclogenesis region. Over the next 13 hours, average bearing shifts from 72º to 55º as the lows follow an increasingly meridional path. Over the next half-day, mean landfall occurs on northern Vancouver Island with a track bearing of approximately 40º.

Region	Avg	Max	Min	Median	Q1	Q3	IQR	Std Dev	Skewness	Kurtosis
Central Pressure (kPa)										
a	100.0	101.0	97.3	100.4	99.83	100.88	1.05	1.17	-1.30	3.47
b	99.4	100.9	97.3	99.5	98.93	100.18	1.25	0.93	-0.64	2.98
c	97.9	99.5	95.9	97.7	97.24	98.73	1.49	0.96	-0.13	2.21
d	98.7	99.9	99.7	98.6	98.13	99.30	1.18	0.77	0.08	2.01
Central Pressure Tendency (hPa [6] h^{-1})										
a	-2.7	1	-6	-2.8	-4	-1	3	2.05	0.06	-1.19
b	-3.9	0	-10	-4.5	-6	0	6	3.17	-0.06	1.92
c	-5.7	1	-17	-5.0	-7	-2	5	4.69	-0.87	3.33
d	6.1	14	-2	4.5	3	9	6	4.50	0.22	2.04
Storm Forward Speed (km h^{-1})										
a	81.5	117.6	46.1	80.4	72.8	87.9	15.1	20.52	0.25	2.61
b	73.6	126.0	0.0	76.6	55.8	103.5	47.6	37.29	-0.47	2.28
c	64.5	132.3	34.0	57.2	47.4	74.4	27.0	27.82	1.29	3.86
d	48.9	82.4	20.0	47.9	38.9	59.4	20.5	17.16	0.32	2.40
Storm Path Bearing (º)										
a	72.2	105.9	44.1	70.8	66.1	80.0	13.9	15.35	0.38	3.60
b	71.6	108.7	0.0	74.7	51.2	93.3	42.0	29.82	-0.99	3.51
c	55.1	174.6	19.5	45.8	38.2	58.2	20.0	37.20	2.19	7.27
d	40.0	113.3	6.8	31.0	23.9	50.5	26.6	25.38	1.32	4.72
Latitude (º)										
a	40.3	46.2	32.0	40.2	37.0	43.6	6.6	4.41	-0.24	2.04
b	42.2	46.0	37.5	42.0	41.1	44.4	3.3	2.51	-0.39	2.16
c	46.5	49.3	42.8	46.8	45.5	48.3	2.8	1.93	-0.49	2.38
d	51.9	54.5	49.5	51.3	50.8	53.8	2.9	1.69	0.30	1.75
Longitude (º)										
a	-163.9	-145.5	-205.5	-158.7	-170.3	-150.9	19.4	18.14	-1.28	3.52
b	-138.9	-135.0	-143.0	-138.8	-140.6	-136.8	3.8	2.51	-0.05	1.99
c	-129.6	-128.3	-131.6	-129.6	-130.1	-128.8	1.3	0.92	-0.53	2.45
d	-124.8	-121.5	-129.2	-125.0	-125.7	-123.5	2.2	1.95	-0.30	2.88

Table 2: For the 22 southeasterly windstorms that moved through the trackway during 1994-2016, regional averages of central pressure (kPa), central pressure tendency (hPa [6] h^{-1}), storm forward speed (km h^{-1}), storm path bearing (°), latitude (°) and longitude (°). Not every windstorm tracked through each of the developmental regions and the number of observations varies from 12-19.

Storm forward speed tends to be at its fastest far offshore, with a mean of 81 km h^{-1}. This is reduced by 40% as the storms approach the coast and track into BC. With an average delta of 16 km h^{-1} between the maximum development and cyclolysis regions compared to 7 km h^{-1} for the incipient and cyclogenesis regions, it appears that the slowing is strongest as the storms reach the coast and move inland.

Mean rates of central pressure reduction—deepening—starts off at a modest -2.7 hPa (6) h^{-1} in the incipient cyclone stage, with a gradual escalation to a fairly quick -5.6 hPa (6) h^{-1} during the peak development phase. During cyclolysis, rates of pressure increase—filling—are also quite rapid on average. If the mean central pressure of 100.0 kPa for the incipient stage is taken as a starting point, then the average southeasterly windstorm deepens by 21 kPa on average, reaching 97.9 kPa at peak intensity over the span of roughly 36 h. As southeasters track inland, they tend to fill to about 98.7 hPa over the next half day. The entire developmental sequence takes approximately two days depending on the storm.

Discussion: Southeaster Trackway Trends

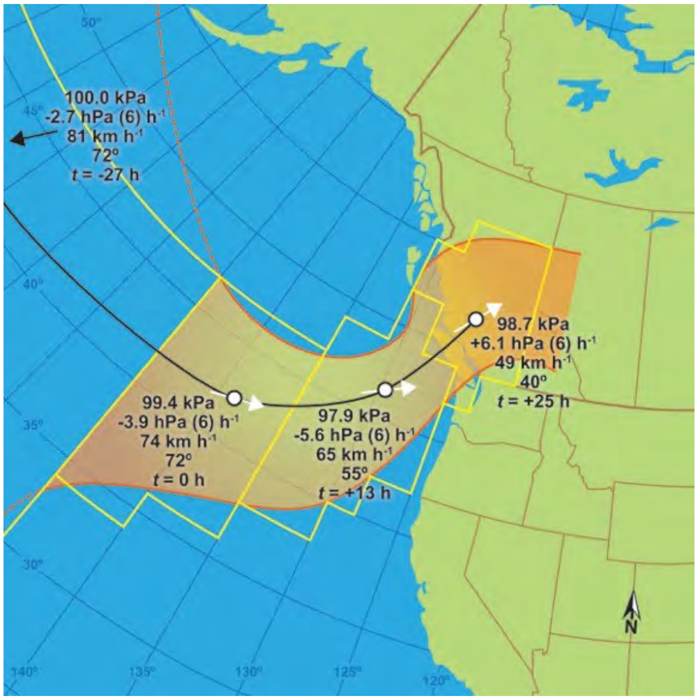

Figure 6: For 22 extratropical cyclones that moved through the Southeaster Trackway and generated high winds at the major population centers of southwest BC, summary statistics in each developmental region. Shown are the mean position of the low-pressure centers (white-filled circles), mean central pressure in kPa, mean central pressure tendency in hPa (6) h^{-1}, mean forward speed of the storm in km h^{-1} and mean storm track bearing in degrees, also indicated with the white arrows. Times are relative to the cyclogenesis region, and are approximate.

Explosively developing cyclones—cyclogenic bombs—have received much attention given their potential for producing extreme weather (e.g. Sanders and Gyakum 1980, Reed and Albright 1986, Selier and Zwiers 2015a, Selier and Zwiers 2015b). The basic definition of explosive development for an extratropical cyclone is a deepening rate of 24 hPa (24) h^{-1} at reference latitude 60º (Sanders and Gyakum 1980). This cutoff is modified across latitude by applying the formula sinϕ / sin60. If the average latitude of the analyzed storms, 46.1ºN, is used as the reference point for the southeasterly windstorms that affected the study region, then any deepening rate of ≥20 hPa (24) h^{-1} can be regarded as explosive development.

With an intensification rate of 21 hPa from *t* -27 h to *t* +13 h (Figure 6), or approximately 40 h, the average southeaster during the study period apparently did not qualify as a cyclogenic bomb under the strict definition. However, if the focus is shifted to a finer temporal scale of 6 h, the time interval used for storm track determination, the picture changes. A rate of ≥20 hPa (24) h^{-1} is equivalent to ≥5 hPa (6) h^{-1}. The average southeaster deepened 5.6 hPa (6) h^{-1} while passing through the maximum development region. This suggests that intensification rates tended to reach explosive cyclongenesis magnitude for at least a brief period when storms were near peak intensity. This is also reflected in the 15 hPa change in mean central pressure between *t* 0 and *t* +13 h, indicating an average deepening rate of nearly 1.2 hPa h^{-1} (i.e. >24 hPa (24) h^{-1}).

The sample of southeasters had an average minimum central pressure of 97.9 kPa (Table 2, Figure 6). This fits well with the common wisdom of windstorms in the region where minimum central pressures ≤98.0 kPa are thought to have the greatest likelihood of producing high winds (Mass and Dotson 2010). There are, of course, exceptions to this rule-of-thumb, as storms with relatively high central pressures can sometimes trigger damaging winds (Mass and Dotson 2010, Read 2015).

The rapid filling rate post landfall, as indicated in the statistics for the cyclolysis region (Table 2, Figure 6), is classic. The Northeast Pacific has been referred to as an extratropical cyclone graveyard (Mesquita et al. 2009). The outcome for southeasterly windstorms in the trackway supports the characterization, with many low-pressure centers quickly loosing strength as they move inland, and becoming absorbed. Some rare exceptions have been documented (Read 2015).

When considering storm forward motion, there is a gradual slowdown in speed as the extratropical cyclones near the North American coast (Table 2, Figure 6). Terrain interaction apparently has an effect on these storms even >1,000 km offshore, causing the weather systems to gradually slow. This distance is about what would be expected given estimates of the internal Rossby radius of deformation for the mean latitude of the storm track in the region ahead of path recurvature. Forward motion slows most rapidly in the cycloysis region, essentially when the storms near shore. This speed reduction may contribute to two important outcomes: 1) the potential protraction of near-surface high winds since it takes longer for the storm to make landfall and then depart; and 2) allowing more time for filling before the low-pressure center reaches its closest approach to the study area, thereby possibly mitigating to some extent the peak wind magnitude.

The tendency for recurvature to the northeast and north is a situation that supports strong south to southeast winds (Lynott and Cramer 1966, Mass and Dotson 2010, Read 2016). The vector of storm motion can add to winds with a southerly component. Given the direction the storms are travelling as they land on the coast, upper-level winds are likely to be roughly aligned with the storm motion vector and therefore could contribute momentum to near-surface winds provided that a vertical mixing mechanism is in place. Also, as the extratropical cyclones track inland the orientation of the pressure gradient field—or pressure slope (Lange 1998)—is typically supportive of strong southeast ageostrophic winds in the study region.

Conclusions

Many extratropical cyclones that affect the southwest BC interior with high southeasterly winds begin development far offshore over the Northeast Pacific, typically west of 135º and south of 47º. Initial storm motion tends to be east-northeast, then recurving to the northeast and north-northeast as they near the coastline of North America. Landfall is often on Vancouver Island, putting the storm center close to the major population centers, including Victoria and Vancouver. Thus describes the Southeaster Trackway.

Despite bringing high winds to the interior regions of southwest BC, the central pressure of extratropical cyclones in the trackway generally does not reduce at a rate that meets the strict 24-h definition of explosive cyclogenesis. This has implications for any study that limits its analysis to the strict definition, since a large proportion of high-wind generating storms would be excluded from examination. However, when central pressure tendencies are assessed at a finer temporal scale of 6-h increments, average deepening rates clearly reach and even exceed the minimum requirements in many cases. Central pressure tendencies appear to escalate as the storms develop, reaching maximum within a narrow 12-h time window as the low-pressure centers recurve off of the Oregon-Washington coastline. It is recommended that extreme storm analyses use shorter time increments than 24 h when isolating storms for consideration.

Storm forward speed reduces by about 40% on average as the extratropical cyclones near the Pacific Coast of North America. This reduction in speed likely protracts the period of high winds in the study region relative to what it might be. However, the slowing may also mitigate the peak wind magnitude somewhat, since the lows have more time to weaken before reaching their closest approach to the study area.

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About Wolf

Wolf Read is currently a Sessional Instructor for the School of Resource and Environmental Management at Simon Fraser University. For his doctoral dissertation, he studied the climatology and meteorology of southwest British Columbia windstorms and associated tree-related power outages at the University of British Columbia. In his spare time, he has been known to write and illustrate science fiction, and get lost in the woods with his camera while looking for interesting vegetation and birds.

Sea Ice and Lake Ice Thickness Observations with CryoSat

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Justin F. Beckers, Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Canada

In response to ever changing sea ice conditions, and recognizing the need for better understanding and prediction, the European Space Agency (ESA) launched the CryoSat mission. It is the first satellite mission dedicated to the observation of Arctic and Antarctic sea ice thickness. After the original satellite was lost in a launch failure in October 2005, a new satellite, CryoSat-2, was immediately built and launched in April 2010. CryoSat reaches latitudes up to 88° North and South, and therefore covers larger regions of the Arctic than previous ESA missions or NASA's ICESat satellite.

CryoSat measures the thickness of sea ice by means of radar altimetry. It carries a novel, Ku-Band (13.6 GHz) Synthetic-Aperture Interferometric Radar Altimeter (SIRAL) which has a smaller footprint and higher spatial along-track resolution than conventional satellite radar altimeters (Wingham et al., 2006). SIRAL's across track, pulse-limited footprint is approximately 1.67 km, and its sharpened beam-limited along-track footprint is only 0.31 km. The high along-track resolution allows for better discrimination of ice floes and open water leads which is needed for accurate freeboard and thickness retrievals as will be described in the next section.

Ice thickness products have been generated by various groups in the UK (e.g. Laxon et al., 2013; Tilling et al., 2015), US (e.g. Kurtz et al., 2014; Kwok and Cunningham, 2015), and Germany (e.g. Ricker et al., 2014; Figure 1), and experiences from these are continuously utilized by ESA to improve their own operational products. Because radar altimetry only yields one-dimensional data within the radar footprint along the satellite's ground track, regional coverage critically depends on orbit geometry and revisit times. CryoSat's orbit has a repeat cycle of 369 days with a sub-cycle of one month (see also Figure 4). Therefore, most Arctic-wide thickness maps are produced by averaging monthly data on grid sizes of, e.g., 25x25 km^2 (see e.g. Figure 1). In summer, due to the presence of wet snow or melt ponds, radar reflections are spurious and ice and water cannot be well distinguished. Therefore Arctic ice thickness can only be retrieved reliably between October and May of each year.

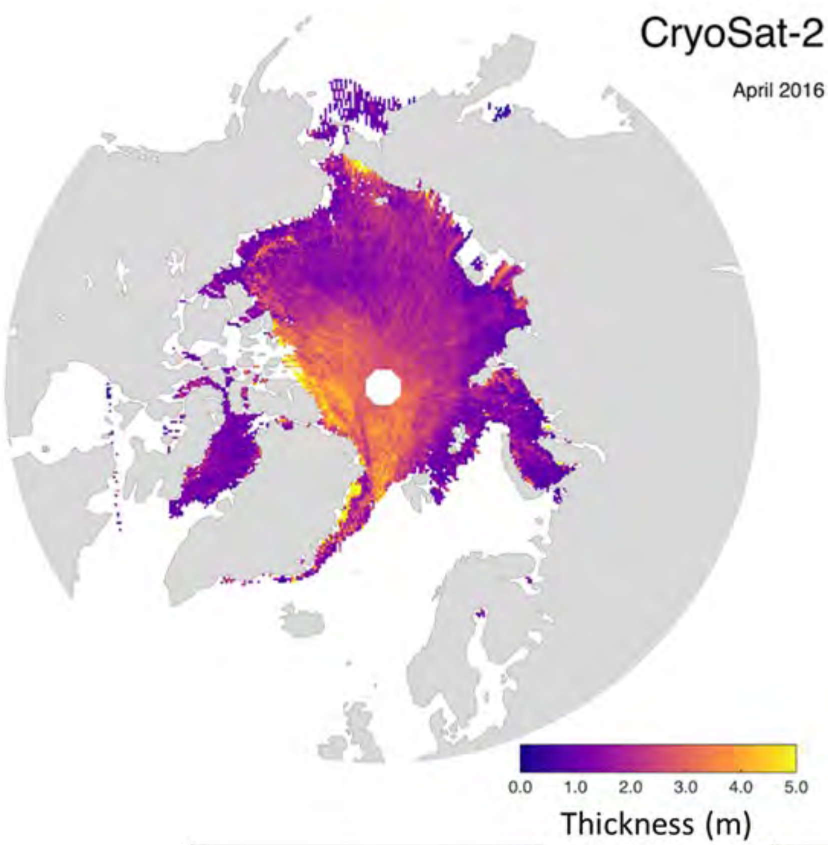

Figure 1: Typical CryoSat monthly ice thickness map. This example shows ice thicknesses in April 2016, representing initial conditions at the onset of the 2016 melting season. Data from http://www.meereisportal.de (Ricker et al., 2014).

Using complementary satellite derived ice concentration data, CryoSat ice thickness retrievals have been used to compute seasonal and interannual variations of Arctic sea ice volume that are in good agreement with model estimates (e.g. Laxon et al., 2013; Tilling et al., 2015). Kwok and Cunningham (2015) have combined submarine, ICESat, and CryoSat data since 1980 to show the continuing thinning of Arctic sea ice, which somewhat slowed during the CryoSat observation period.

Uncertainties and Validation

Ice thickness cannot be obtained directly from radar altimetry, but requires numerous processing steps and the use of auxiliary data. The primary observable of radar altimetry is the Earth's and Ocean's surface height. In the case of a sea ice cover, the surface is composed of ice floes and open water leads. The sea surface height (SSH) of leads can be taken as a reference for the elevation of ice floes above the local water level. This elevation is called ice freeboard. Ice thickness can be calculated from ice freeboard using Archimedes' Principle when the densities of water, ice, and snow as well as snow thickness are known. Uncertainties in these parameters, in particular of snow thickness, can lead to errors as large as 30% (e.g. Kwok and Cunningham, 2008) given that the freeboard-to-thickness ratio of floating ice is of the order of 1/10 (remember the ice cube in your Whiskey).

But freeboard retrievals themselves can have high uncertainties too, for at least three main reasons: First, accurate height retrievals are only obtained by "retracking" of the time-resolved radar return (the "radar waveform"). This retracking adjusts the time delay of the radar's receive window to the actual distance to the Earth surface, accurate within centimeters. However, different empirical or theoretical methods can be used for retracking causing freeboard biases of up to 0.12 m (Kurtz et al., 2014; Ricker et al., 2014). Second, unresolved geoid undulations and variable dynamic sea surface topography affect the actual SSH but remain undetected where no leads are nearby, or when leads are misidentified. Finally, it is unclear if the radar scattering horizon, i.e. the height within the snow from where the main radar energy is scattered back to the satellite, really coincides with the ice surface as is commonly assumed. Insufficient penetration of the radar signals to the snow/ice-interface will cause overestimations of freeboard. In order to assess these uncertainties validation of CryoSat freeboard and thickness retrievals is crucial.

Our activities at the University of Alberta and York University have primarily contributed to validation efforts of the accuracy of CryoSat thickness retrievals (Haas, 2002). With our unique capability to perform large-scale airborne electromagnetic (EM) ice thickness surveys (e.g. Haas et al., 2010), we have carried out CryoSat underflights over distances of 100s of kilometers of ground track. Together with other group's upward-looking sonar (ULS) and laser altimetry measurements these are the primary means of CryoSat validation (Laxon et al., 2013; Kurtz et al., 2014; Kwok and Cunningham, 2015; Tilling et al., 2015). In most cases, monthly gridded CryoSat data are compared with the nearest available validation data sets. Results show that correlation coefficients R between CryoSat and other thickness observations range between 0.5 and 0.9, with RMS differences between 0.7 and 1 m (see example in Figure 2). The large small-scale variability of sea ice and different footprints and temporal and spatial resolutions of the different methods make validation quite challenging.

During our validation campaigns, we also carried out extensive in-situ measurements on first-and multiyear ice in the Beaufort Sea and north of Ellesmere Island. Particular attention was paid to the acquisition of coincident snow property and airborne radar data to better understand radar penetration. These studies were also coordinated with NASA's Operation IceBridge and in particular with their snow radar. Results showed that radar penetration into the snow is very variable and that coincidence of the radar scattering horizon and the ice surface cannot be generally assumed (Willat et al., 2011; Kwok and Haas, 2015; King et al., 2015). However, there is great potential in improving airborne snow radar performance and coordination of airborne and satellite surveys to minimize snow thickness uncertainty and improve ice thickness retrievals.

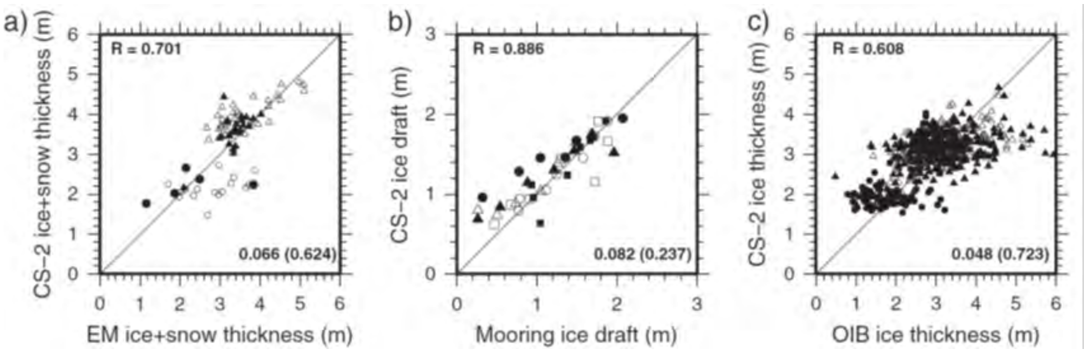

Figure 2: Comparison of CryoSat thickness retrievals with validation data from airborne EM surveys (a), moored ULS (b), and laser altimetry (Operation IceBridge OIB, (c)), from two different years (open and closed symbols). Different symbols show data from first-year ice or multiyear ice, respectively. Numbers indicate correlation coefficients (R), mean and rms differences (in parentheses, in meters). Figure from Laxon et al. (2013).

Lake ice thickness retrievals

While looking for CryoSat returns from uniform ice surfaces to better understand the dependence of waveform characteristics on ice and snow properties, we turned to measurements over Great Bear and Great Slave Lakes in Canada. Amazingly, we found that waveforms over lake ice are clearly characterized by the presence of two peaks, representing reflections from the ice surface and from the ice bottom (Beckers et al, in press), and that lake ice thickness can be derived from the travel time difference between those, like is done in ground-penetrating radar surveys and taking into account radar propagation speed in ice. As Figures 3a+b demonstrate, the two waveform peaks clearly separate as the ice thickens. During the melt and open water seasons the waveforms show the same behavior as over sea ice, i.e. minimal penetration in wet snow, and dependence on wind roughening during the open water season. While Ku-Band radar penetration into freshwater ice has been observed before (see summary in Beckers et al., in press), application for lake ice measurements certainly benefited from the small CryoSat SAR footprints. The differences between data from lake and sea ice also demonstrate the difficulties posed by salinity and footprint-scale surface roughness of sea ice for radar penetration and coherent scattering.

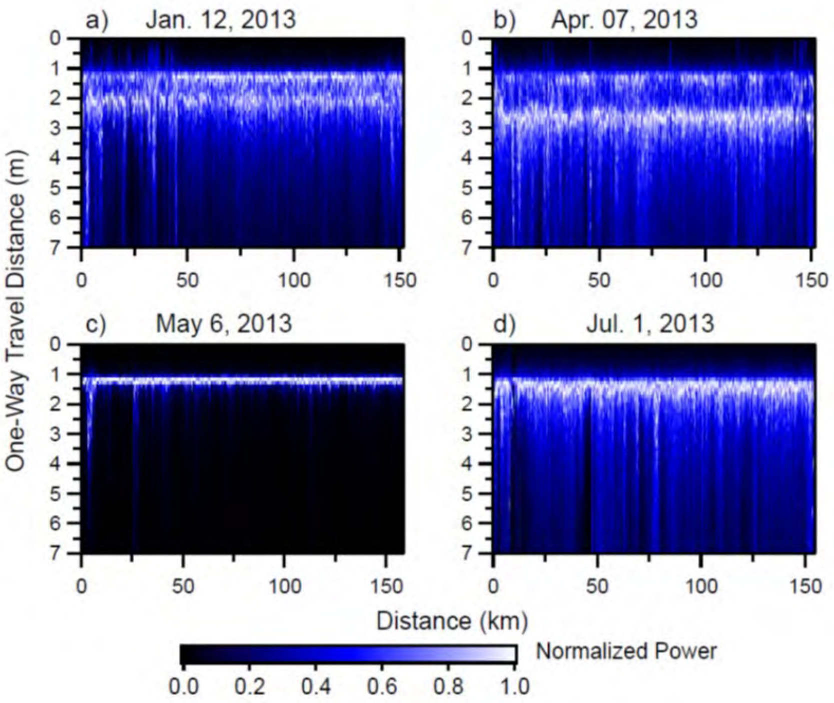

Figure 3: Lake ice thickness measurements demonstrated by typical CryoSat waveform data from four orbits over Great Slave Lake in 2013, in early and late winter (a,b), and during the melt and open water seasons (c,d). Distance (km) along the track is displayed on the x-axis. Waveform delay time is plotted on the y-axis, converted to one-way travel distance using the speed of light in free space, i.e. before conversion to ice thickness. Grey scale shows normalized power from 0 to 1. From Beckers et al. (in press).

Near-Real-Time (NRT) data for seasonal predictions and in support of marine operations?

The need for auxiliary orbit, geophysical, atmospheric, and sea ice information for processing and correcting CryoSat data, and their limited spatio-temporal coverage due to CryoSat's inherent orbit geometry and spatial resolution (Figure 4) has meant that CryoSat thickness data had a latency of at least a month after data acquisition, and that maps had coarse spatial and monthly temporal scales. This makes them invaluable for Arctic-wide, seasonal or interannual studies. However, there is a need for more timely information in support of seasonal predictions and marine operations.

Tilling et al. (2016) have demonstrated that it is technically feasible to produce thickness data within three days of a CryoSat overpass with hardly any loss of accuracy, and that a measurement is delivered, on average, within 14, 7 and 6 km of each location in the Arctic every 2, 14 and 28 days respectively (Figure 4). Coverage improves with increasing northern latitude. However, such individual measurements are characterized by high point-to-point noise and uncertainties are much larger than stated above for grid-averaged products. Tilling et al. (2016) estimate that errors can be larger than those by as much as 32% for a 2-day 5 km gridded product.

While the value of promptly disseminated products of coarse monthly ice thickness fields with reasonable accuracy for seasonal prediction with forecast models can be well imagined, the usefulness of products with higher spatial resolution but less spatial coverage and higher uncertainty remains to be seen. Safe and efficient marine operations and shipping rely on knowledge of small-scale thickness variability and the occurrence of thick ice and extreme ice features which may remain undetected due to the satellite measurements' incomplete spatial coverage, footprint size, and noise characteristics.

Further recent advances in CryoSat product generation include merging of CryoSat with SMOS thickness data. The ESA SMOS satellite operates a 65 km resolution, L-Band passive microwave radiometer which can sense ice thicknesses up to 1 m, i.e. the thickness of thin ice where CryoSat thickness retrievals have the largest uncertainties. The issue of inaccurate snow thickness and snow penetration information could be improved by combinations of CryoSat Ku-Band and novel French AltiKa Ka-Band (35.75 GHz) radar altimetry which have different snow penetration characteristics.

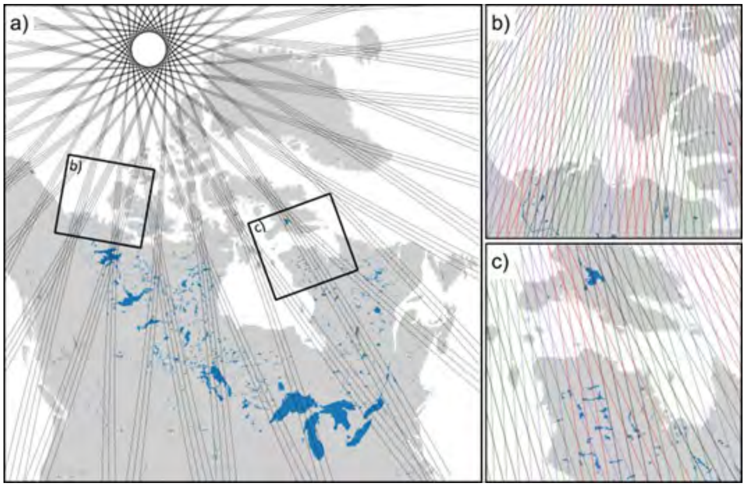

Figure 4: a) Example of all CryoSat ground tracks along which ice thickness data are obtained during one week. b&c) Example of all CryoSat ground tracks along which ice thickness data are obtained during four weeks of observations, i.e. during one sub cycle within the 369 days exact revisit cycle. Each week's ground tracks are indicated by a different color. Maps show examples for the Beaufort Sea/Amundsen Gulf (b) and Hudson Strait regions (c), two shipping hotspots in the Canadian Arctic.

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Prof. Christian Haas is Canada Research Chair for Sea Ice Geophysics at York University and is also affiliated with the Alfred Wegener Institute for Polar and Marine Research in Germany. His research is concerned with the role of sea ice in the climate, eco-, and human systems. Christian studies sea ice and in particular ice thickness variations by means of satellite and airborne remote sensing and in-situ measurements, e.g. during snowmobile surveys with hunters in the Canadian Arctic. He is also the coordinator of the European Space Agency's CryoSat validation team.

North-American CryoSat Science Meeting

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CryoSat 2017 will provide a unique and timely forum for scientists and end-users of CryoSat data to share the state-of-the-art in research and applications, review mission achievements and prepare for the continued use of the CryoSat mission in the future. It will highlight areas where the mission has made significant contributions including cryosphere, oceanography, geodesy, hydrology, topography, meteorology and climate change.

Cryosat 2017 is part of a broader 2017 ESA Earth Explorer science meeting, which also includes the Fourth Swarm Science Meeting and Geodetic Mission Workshop.

Abstract submission deadline: **4 December 2016**
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Pre-registration for the conference is mandatory for all participants.
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50th Anniversary: Interviews

To celebrate the 50th anniversary of CMOS, the Society will be publishing a book, to include a compilation of papers published in the CMOS flagship journal *Atmosphere-Ocean*. The republished papers were selected from all papers published in *Atmosphere-Ocean*, and its predecessor *Atmosphere,* on the basis of being the most-cited papers in the past five years.

In the first three issues of Volume 45 of the CMOS Bulletin, readers can enjoy interviews conducted by CMOS Bulletin Editor Sarah Knight with the authors of the papers included in the book. The book will be available in time for the June CMOS Congress in Toronto.

Interview with Éva Mekis

Dr. Éva Mekis is the lead author on two of the papers included in the book, and a co-author on a third. Here, she answers questions relating to both her 1999 and 2011 papers (co-authored by William Hogg and Lucie Vincent, respectively) on the first and second generations of adjusted daily precipitation measurements used mainly in trends analysis and hydrological studies in Canada.

Q: *How did you get interested in this topic, and what motivated you to pursue this area of research?*

Since the beginning of my career I was involved with multiple aspects of precipitation. In the 1990's my supervisor Bill Hogg at the Hydrometeorology Division of Environment Canada realised the need for adjusting the instrument related errors. Due to my dual statistical and meteorological background I was assigned to this project. The adjustments for each rain gauge type, wind undercatch, evaporation and wetting losses; for snowfall density adjustments and additional factors for trace observations completed and its impact on the magnitude and trend were examined. Observations from nearby stations were sometimes merged together in order to create long time series useful for trend studies. I enjoyed the task and responsibility.

Q: How, since publication, has this research informed meteorological research, in Canada or around the world?

Rain and snow observations contain several measurement issues associated with the instrument's type and location. If these issues are not accounted for properly, the results of any climate trend and hydrological analyses using these data can be erroneous. Due to our publications of the adjusted precipitation datasets and its impact studies the Canadian scientists and even the public became aware of the large observation errors and the need for correction in the water balance. Hundreds of users requested and applied these datasets in various studies mainly in Canada and US.

Éva is pictured here in 2015, South of lake Simcoe. during the PanAm Games with the AMMOS (car top) station.

Éva in 2002 at the Caribou Poker Creeks Research Watershed, Alaska, with a precipitation gauge surrounded with Tretyakov shield.

Q: What do you perceive was the main impact of this research?

The adjusted precipitation dataset in Canada is of particular importance in climate and water balance analyses. The scientific information resulting from these studies help the scientific community to better understand the importance and advantage of using adjusted and occasionally homogenized precipitation dataset compared to conventional climate observations. The adjustments affected not only the precipitation amounts but also the long term trends. It is widely distributed to the climate research community and the data are available via a website.

Q: How did this research inform your own research goals, and what areas have you moved in to since?

It was fulfilling to see the usefulness of my adjusted daily and monthly precipitation datasets and my trend analysis. My main research area is still connected to precipitation. Together with my colleague Lucie Vincent we computed several indices of daily and extreme temperature and precipitation, analysed the obtained trends and variations based on the adjusted and homogenised time-series. Next I studied the observed trends in severe weather conditions based on humidex, wind chill and heavy rainfall events across Canada. In the last two years I completed an overview of surface based precipitation observations within ECCC network. Presently I am also participating in the Solid Precipitation Intercomparison Experiment (SPICE) WMO project.

Q: What are your research plans for the future?

Due to the systematic automation of the manual measurement programs across Canada the combination of manual and auto observations became extremely important. In the last 3 years I am involved in the development of climate and gauge dependent catch efficiency algorithms using wind, supplementary instruments and temperature dependent transfer functions between the different observing systems.

I also continue my severe weather analysis, this time with the focus on near 0° C freezing weather conditions.

Beside of my research topics I regularly provide specialized climate data and consultation and analysis for requests by stakeholders and scientists from universities, regional offices and other departments.

Q: What are your hopes for meteorological research in general, in the future? What is your opinion on what research areas should be prioritized?

Precipitation at the surface is one of the most important parameters from a meteorological observing system. It is also extremely challenging to measure due to its high spatial variability and the many phases in which precipitation can occur. It is a fact that the number of manual stations with long term good quality records that are core to detect changes in climate are decreasing. More focus should be given to the availability of further precipitation related parameters (like precipitation type and the snowfall amount) from the in-situ operational automatic stations.

Furthermore, precipitation has a level of uncertainty at the source due to the weather dependent errors associated to individual instrument performances (e.g. wind induced error, freezing conditions, spatial variability), especially for solid precipitation. Climate and gauge dependent catch efficiency algorithms using wind, supplementary instruments and temperature compensation can be developed, which requires that the appropriate sensors for those variables are installed close to the precipitation sensors.

Improved and sustained access to data and metadata from all networks operated by internal and external organizations should also be a primary focus.

One potential way to increase precipitation coverage over Canada's more remote areas could be the integration with satellite missions that employ passive and active technologies for precipitation measurements from space. This approach would require improvements in technology to meet Canadian requirements and commitments to long term operational instruments.

About Éva

Éva graduated in 1980 with a double degree of meteorology and teacher of mathematics from the Eötvös Loránd University (ELTE) Budapest, Hungary. She worked as a research associate from 1980-1988 at the Research Centre for Water Resources Development (VITUKI). During this time she also completed her Ph.D. In 1988 she came to Canada as a Post-Doctoral Fellow (PDF) working with Barry Goodison at the Hydrometeorological Division of Environment Canada (EC). When her scholarship terminated, she went back to Hungary for a short time but returned to Canada and received her indeterminate position at EC in 1994.

Éva is pictured here (far right) with Xiaolan Wang (far left) and co-authors Bill Hogg and Lucie Vincent, on the 2nd Workshop on Climate Data Homogenization, Ashville, in March of 2006.

Paper Summaries

***Rehabilitation and analysis of Canadian daily precipitation time series*; Mekis, É., and Hogg, WD, 1999**

Éva Mekis and William Hogg describe the development of the adjusted daily rainfall and snowfall measurements which are used for trends analysis in Canada. The adjustment procedures removed systematic biases due to changes in the measurement program so climate change detection became achievable. The adjustments described not only remove the inconsistencies for purposes of generating a more homogeneous time series, they also greatly reduce, or ideally, eliminate bias within the full range of the time series. This makes these data much more appropriate for use in water balance studies, runoff analyses and for general model verification purposes. This first generation of adjusted rainfall and snowfall has been used by hundreds of scientists from different government agencies and universities for the analysis of climate change and climate change impacts in Canada.

***An Overview of the Second Generation Adjusted Daily Precipitation Dataset for Trend Analysis in Canada*; Mekis, É. and Vincent, L., 2011**

Éva Mekis and Lucie Vincent present the second generation of adjusted daily precipitation for trend analysis in Canada. Twelve years after the creation of the first generation, it became vital to describe the latest version of the adjusted rainfall and snowfall to properly document the newer methodologies and the impact of changes for the large user community. The impact of adjustments was examined in detail, the rainfall amount increased by 5 to 20% in the Canadian Arctic with the adjustments, while the effect of snow adjustments displayed an even bigger range and variability (from none to up to 50%) throughout the country. By providing adjusted rainfall and snowfall separately, the study of the change in precipitation phase made possible. This dataset is now available at the Government of Canada Open Data portal (http://open.canada.ca/en/open-data) and it is widely used by scientists working in government agencies, universities, and as well by the public in general.

Interview with Stéphane Bélair

Dr. Stéphane Bélair co-authored the 2006 paper *The 15-km version of the Canadian regional forecast system,* describing a mesoscale version of the Global Environmental Multiscale (GEM) model. The developments made by their team, and subsequent developments made by others, have fed into systems used at the Olympics and the Pan American Games.

Q: What motivated you to pursue this area of research?

As a student, after obtaining an engineering degree at École Polytechnique in Montreal, I was first tempted by areas of experimental physics but then I quickly realized that this type of work was not for me. The truth is, I always was fascinated by the idea of using mathematics, physics, and numerical methods to predict the future.

Q: What has been the impact of this research in Canada or around the world?

This article actually presents results from many years of struggle at Environment Canada (now Environment and Climate Change Canada) to develop a configuration of the atmospheric model GEM that was suitable for both regional short-range and global medium-range applications. At the time, my colleague Jocelyn Mailhot (first author of this paper) was responsible for the regional short-range model, while I was responsible for the global medium-range model. Since then, for more than a decade, the configuration of the physical processes that was transferred at the time as CMC's operational deterministic forecasting system is still the basis of what is used today, with recent modifications to numerical aspects of the model and to its assimilation systems. This model configuration has been used by many investigators in Canada for various modelling studies, in academia or government, as part of their publications. At the international level, it is more difficult to identify a specific impact of this study. National environmental prediction centers have their own research programs and develop their own system configurations, but they are certainly aware and influenced by research and development that is performed elsewhere, including here at ECCC.

Q: Subsequently, how did this research inform your own research goals?

The work described in the article was a stepping stone for the operational implementation in 2006 of the 33-km global forecasting system, which I was leading at the time. Having worked so long on this project with all my colleagues at RPN (including Jocelyn), I was happy to shift my interest towards other critical aspects of numerical environmental prediction. In the years following publication of this article, I mostly worked on research and development of more sophisticated modelling and assimilation systems for the land surface. I have also been more interested in atmospheric modelling at the km and sub km scales, with emphasis on urban areas and high-impact weather.

Example of precipitation rates produced by a very high-resolution (250-m grid spacing) version of ECCC's Global Environmental Multiscale (GEM) model.

Q: What are your research plans for the future and what are your hopes for meteorological, or specifically forecasting, research in the future?

My work now and for the foreseeable future is to improve land surface modelling and assimilation, its coupling with the atmosphere, and on sub km-scale atmospheric modelling. My hope is that our community will be able to substantially improve guidance to the public, governments, industry, and anyone else with the current push towards greater higher-resolution modelling, ensemble modelling, and environmental coupled systems. This last item, regarding coupling between weather models and systems for ocean, lakes, hydrological, air quality, and dispersion is particularly important in my mind as it hopefully will solve problems experienced by each community. I am also hopeful that observational and modelling communities will work even more closely together to design future observational experiments or networks that will be optimal in all ways possible.

About Stéphane

Dr. Stéphane Bélair has been a research scientist at the Meteorological Research Division of Environment and Climate Change Canada since 1997. His main interests are in the representation of atmospheric and land surface physical processes, and on high-resolution deterministic numerical weather prediction. Throughout the years Dr. Bélair has been in charge of different research and development projects and groups at ECCC, and member of several national and international committees.

Paper Summary

***The 15-km version of the Canadian regional forecast system*; Mailhot, J., Bélair, S., Lefaivre, L., Biloduau, B., Desgagne, M., Girard, C., Glazer, A., Leduc, AM., Methot, A., Patoine, A., Plante, A., Rahill, A., Robinson, T., Talbot, D., Tremblay, A., Vaillancourt, P., Zadra, A., Qaddouri, A., 2006.**

Jocelyn Mailhot and Stéphane Bélair describe a mesoscale version of the Global Environmental Multiscale (GEM) model implemented operationally at the Canadian Meteorological Centre in May 2004. The major upgrades include increased vertical and horizontal resolution (15 km) and improvements to the physics parameterization package (boundary layer clouds, shallow and deep convection, gravity wave drag and low-level blocking due to subgrid-scale orography). Various aspects of the improved performance of the new system are documented to provide useful guidance to the Canadian operational forecasters community. The development of the GEM 15-km forecast system has also been instrumental for subsequent developments toward kilometer- and sub-kilometer-scale forecast systems, such as the experimental systems used during the Vancouver 2010 and Sochi 2014 Winter Olympics, the Toronto 2015 Pan American Games, and the recently implemented pan-Canadian 2.5-km High Resolution Deterministic Prediction System.

Interview with David Barber

David Barber is the lead author of the 2010 paper *The International Polar Year (IPY) Circumpolar Flaw Lead (CFL) System Study: Overview and the Physical System.* This study brought science teams from 27 different countries together with an Inuit led team that provided local Inuit knowledge to the study.

Q: What motivated you to pursue this area of research?

We have a poor understanding of winter processes in the Arctic Marine System. In particular we are unsure as to the role which polynyas [open stretches of water surrounded by sea ice] play in the physics, biology and geochemistry of polynya processes and how these process scale to local and regional scales.

Q: How, since publication, has this research informed other research in this area, in Canada or around the world?

The work of the CFL project resulted in over 230 peer review publications coming from 27 different countries of origin. This was a primary goal of the International Polar Year - to have countries collaborate both intensively and extensively, to improve our understanding of Arctic processes. There were many 'firsts' in the CFL science output – in fact far too many to mention. The core research results however form the basis for many other Arctic marine studies which have occurred since IPY, and are still being cited today as people prepare for even more extensive examinations of the Arctic marine system.

Q: What were the main impacts and findings of this research?

I would say the main impact is that reductions in ice cover (as illustrated by the polynya) have a very dramatic effect on all aspects of the system. Physically the open water maintained an atmospheric boundary layer with an elevated temperature and water vapour. These effects were not restricted to local scales but were also

Members of the CFL team in the high Arctic, with the CCGS Amundsen in the background.

found at much larger scales. The enthalpy fluxes were such that for the entire winter water the air temperature at the ship (marine climate) was higher than in Winnipeg (continental climate). Biologically the region produces a surprisingly early increase in overall production and it was sustained throughout a longer period than expected due to strong replenishment of nutrients to the euphotic layer. The role of upwelling was also clearly demonstrated during investigation, so was ice edge upwelling adjacent to the polynya. Chemically some of the most interesting results related to how high brine rich surfaces react chemically when the sun returned to the Arctic. This included processes linking photochemistry of methane, bromine, mercury and other halogen species. Frost flowers were ubiquitous in the winter season and their role in over exchange of gas across the OSA interface was a key result of the CFL-IPY project.

Q: What areas of research have you moved in to since?

My group has begun to investigate the higher temporal and spatial forcing functions from both atmospheric and oceanic forcing of the surface. In particular, we have begun to examine the role of storms on the OSA interface. We also have evolved our understanding of very young ice covers and their electromagnetic detection and coupling to chemical exchanges across the OSA interface.

Q: This research involved not only hundreds of scientists from 27 different countries, but also a local Inuit led team – can you comment on the opportunities and challenges of working with such a large and diverse team of people?

Team 10 was by far the largest of our teams. It was led by the Inuit Circumpolar Council (ICC). They did a wonderful job of integrating the Inuit perspective into the other 9 western science teams. This was accomplished by engaging Team 10 into all of the other 9 teams directly in the planning, implementation and presentation of results. Team 10 also conducted their own 'traditional knowledge' study which was conducted in parallel with the western science teams. This knowledge study focused attention on the in depth knowledge the Inuit have of the coastal areas of the IPY-CFL study area and highlight the very strong 'temporal' representation that the Inuit possess. In hindsight it was interesting to me that the western science teams has a strong focus (and strength) on spatial and technological aspects of the study and Inuit had a strong focus on temporal aspect of the study. These 'two ways of knowing' are highly complimentary and resulted in publication of a 287 page coffee table style book that highlighted this 'two ways of knowing' concept as it evolved during the IPY-CFL project (Barber, D.G., and D. Barber (2009). *Two Ways of Knowing: Merging Science and Traditional Knowledge During the Fourth International Polar Year*, University of Manitoba Press. ISBN. 978-0-9813265-0-4.)

Q: What are your research plans for the future?

My group continues its research into the processes which could affect the ocean-sea ice-atmosphere interface and what consequences change and variability have on the rest of the Artic marine system. We also continue to focus on high spatial and temporal forcing of the OSA and look to engage with field work which extends our sampling efforts into the winter season. This coming summer we have a major project in Hudson Bay known as the BaySys project. This is an NSERC CRD project support by Manitoba Hydro which focuses on the relative contributions of hydroelectric regulation and climate change to freshwater-marine coupling in Hudson Bay. This work compliments our Arctic Science Partnership (asp-net.org) research on the role of glacier sources freshwater-marine coupling.

Q: What are your hopes for ocean/atmosphere research in general, in the future?

Hmm. This is a VERY broad question. I think I will answer with a VERY short wish – We need a better understanding of how high frequency events (e.g., storms) affect coupling across the OSA – we then need to figure out a way to include these high frequency event into models.

Q: Climate change is an environmental focal point of this century. If you could send one scientific message to people across Canada, what would it be?

Of the 35+ years I have worked in the Arctic I have gone from being a sceptic (my first decade in the Arctic), to a scientist fascinated with the strong of processes operating across the OSA interface, to a scientists who is growing increasingly concerned that the rate of change we are seeing the Arctic is far larger than the conservative GCM or RCM's are predicting. The public needs to know that international policy objectives are being driven by climate models which are conservative relative to almost everything we are seeing in situ in the Arctic. We need to increase our efforts to reduce GHG emissions as the Arctic is clearly showing us that things are happening much faster than any of us would like.

About David

Dr. David G. Barber received the Bachelor's degree (1981) and Master's degree (1987) from the University of Manitoba, and the Ph.D. degree (1992) from the University of Waterloo, Ontario. He was appointed to a faculty position at the University of Manitoba in 1993 and received a Canada Research Chair in Arctic System Science in 2002. He is currently Associate Dean (Research), CHR Faculty of Environment, Earth and Resources.

Dr. Barber has published over 240 articles in the peer reviewed literature pertaining to sea ice dynamic and thermodynamic processes, remote sensing of sea ice, climate change and physical-biological coupling in the Arctic marine system (www.umanitoba.ca/ceos). He is a fellow of the Royal Society of Canada (Science Academy), an Officer of the Order of Canada, and a UM Distinguished Professor.

Paper Summary

***The International Polar Year (IPY) Circumpolar Flaw Lead (CFL) System Study: Overview and the Physical System*; Barber, D. G., Asplin, M. G., GraUon, Y., Lukovich, J. V., Galley, R. J., Raddatz, R. L., Leitch, D., 2010**

David Barber writes with regards to the International Polar Year (IPY) Circumpolar Flaw Lead (CFL) system study, conducted between 2007 and 2011, aboard the fully outfitted research icebreaker (CCGS Amundsen). The project brought together over 450 investigators from 27 different countries in a first ever project designed to examine winter processes on ocean-sea ice-atmosphere coupling. The study clarified a number of key processes and in particular brought focus on the fact that winter processes are highly sensitive to high frequency events such as storms. An Inuit led team brought Inuit knowledge to the study and fully integrated this with 9 science teams allowing for full system examination. The study was also testament to the fact that 20 years ago a study like this would not have been possible due to extreme ice features in the southern limb of the Beaufort Sea ice gyre. Climate change effects were clearly evident and key enabling feature of this unique study.

In Brief: Top Ten Weather Stories

Canada’s Top Ten Weather Stories, 2016

David Phillips, Senior Climatologist, Meteorological Service of Canada, Environment Canada, Downsview, Ontario

The most notable weather events was started in 1996 and is compiled by David Phillips, Canada's foremost weather guru. The top Canadian weather stories for 2016 are ranked from one to ten based on factors that include the impact they had on Canada and Canadians, the extent of the area affected, economic effects and longevity as a top news story.

The fire storm of Fort McMurray will never be forgotten by Canadians, and it’s no wonder to find this event topping the list. Melting Arctic Sea ice, one of the warmest Novembers on record, and a summertime to remember for happy cottage-goers in the East also made the top ten. Here, a short summary of each is presented; more details on each on the CMOS website (http://cmos.ca/site/top_ten)

1. McMurray’s “Fire Beast”

The El Niño-influenced winter-spring was the driest in 72 years of weather recordings at Fort McMurray and the second warmest on record. Weeks of warm, dry weather created a bone-dry forest floor – the perfect breeding conditions for a fire storm with Fort McMurray at the epicentre. On May 1st the fire started, was quickly contained, but then blew out of control due to blustery winds. Within two days, the fire had doubled in size, and Fort McMurray’s 88,000 residents were then ordered to leave town causing a mass exodus of natural disaster refugees. By May 4th the wildfire could be seen from space. Nicknamed “The Beast”, the wildfire became the costliest catastrophe in Canadian history with total costs reaching $4 billion in insured losses and billions more in lost business, infrastructure and uninsured losses.

2. Super El Niño Cancels Winter

Winter 2015-2016 was the second warmest winter since country-wide records began in 1948. A persistent “super” El Niño got much of the credit for the missing winter globally and in Canada. Another consideration was shrinking Arctic sea ice, which has been thinning and retreating to record levels in recent years. Regina had its second warmest winter with records going back to 1883 and not a single February day below -20°C. Farther east, there had never been a milder winter in Moncton in at least 60 years. Across the country, the record mild winter had a major impact – both negative and positive. While it meant an extraordinarily short ice road season, it also eradicated the threat of spring flooding for most parts of the country. In the East, ski resorts saw one of the poorest seasons in memory.

3. August Long Weekend Storm on the Prairies … Big and Costly

July was a month of stormy weather across the Prairies, but the storm on the August 1 long weekend had the most far-reaching and expensive impacts. On July 30, an intense low pressure system with an accompanying cold front swept through Alberta and continued into the eastern Prairies the next day. Wind, rain and hail battered homes, shattered windows, lifted roof shingles and damaged several commercial airplanes. As the storm rolled through Edmonton, it flooded Whitemud Drive and stranded motorists for the second time in a week. Further north, Fort McMurray was once again a target. Twelve weeks after they couldn’t get a drop of rain, the fire-ravaged city was pounded with more than a month’s worth of rain in two hours (87 mm). Insurance claims numbered 42,000 and losses totalled $410 million, with the vast majority in Alberta.

4. A Summer to Remember in the East

Summer weather arrived in the East on the Victoria Day weekend, and it stayed consistently hot, humid, almost dry and fairly quiet past Labour Day. At Toronto Pearson International Airport, there were 39 days with maximum temperatures at or above 30°C compared to a normal 14. Despite excessive heat, the province recorded only one smog and air health advisory. But what was good for campers and beachgoers, was bad for farmers and gardeners. A prolonged drought prevailed across a broad swath of Ontario, from Chatham north to Ottawa and into Quebec and Nova Scotia. At Yarmouth, rainfall totals from June 1 to mid-September were less than 30% of normal. In spite of stringent bans, water levels steadily dropped to the point where the inland Nova Scotia fishery virtually shut down. In the Niagara region, farmers were desperate for rain. For the first time in nearly 20 years, some vintners resorted to irrigating their vineyards.

5. November's Heat Wave and December's Deep Freeze

Early October seemed too soon for wind chills and blowing snow on the Prairies. Luckily, October's false winter ended before Hallowe'en with a remarkable warm-up. By mid-November, more than 300 daily records had fallen across the West and North − some by an incredible five degrees or more. With a new month came different weather. In the first week of December, a mass of Arctic air swept southward across British Columbia, east into the Prairies and Northern Ontario. The frigid air gripped the West for two weeks with temperatures at times 15 degrees below average and wind chills of -40 and below. Tragically, the bone-chilling cold cost several Canadians their lives. For the homeless, the bitter cold made a hard life harder. Millions of Canadians cranked up the thermostat to beat back the cold, pushing up power usage to record loads on the Prairies. Southeastern Saskatchewan and Southern Manitoba were walloped by a huge pre-winter storm dumping 20 to 50 cm of snow leading to school and highway closings, and roof collapses. By mid-month, Easterners were re-introduced to the dreaded Polar Vortex, the Colorado low, and associated snow squalls. The frigid air didn't loosen its grip until the first official day of winter but did ensure that millions of Canadians had a white Christmas.

6. Arctic Sea Ice Going, Going …

The Arctic sea ice maximum in March was a fraction above last year's record low − not surprising given the exceptionally warm weather at the top of the world, which was 2 to 6°C above average. With an abundance of fairly thin ice in the Arctic Ocean at the beginning of the melt season, there was a good chance that the minimum ice extent in mid- to late-September would once again be close to a record low in 2016 and that's exactly what happened. According to the Canadian Ice Service, Arctic waters in Canada had their third lowest minimum ice coverage on record (2012 had the lowest; 2011 the second lowest). In the Beaufort Sea, mid-September sea ice was at its second lowest minimum coverage. The freeze-up started on time, but with the large area of open water, it wasn't until the end of November that ice cover was expansive – a remarkable four weeks later than normal.

7. Wild Summer Prairie Weather

Weather forecasters were kept busy on the Prairies this summer with one of the longest and most active storm seasons ever since statistics were first kept in 1991. Clusters of intense thunderstorms were more frequent and seemed to move slower than usual, taking longer to spread their misery. There were numerous reports of large


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hail, heavy rain, high winds, frequent lightning and countless localized events that included tornadoes, brief non-destructive landspouts and microbursts. Tornadoes were much more frequent − 46 vortices compared to the 30-year average of 34. There were also 564 severe weather events (large hail, strong winds, heavy rain and tornadoes), which is over twice the normal number, with payouts for crop hail insurance claims coming in at 50% higher than last year's figures and well above the five-year average.

8. A Tale of Two Springs

Summery in the West

British Columbia, the Yukon and the three Prairie provinces experienced their warmest spring in nearly 70 years of record-keeping – up to 4.5 degrees warmer than normal. By mid-May, forests were bone dry, humidity was low, and winds were strong and gusty, which raised the wildfire threat from high to extreme. On May 4, temperatures soared in Winnipeg to an unbelievable 35.2°C. It was the city's earliest 35°C reading since records began in 1872 and, as it turned out, it was the highest temperature of any day in 2016 − a good seven weeks before the official start of summer.

Wintry in the East

Unfortunately for those in much of southern Ontario and Quebec, winter delayed its arrival until spring. For the first week of April, temperatures plummeted with new record minimum temperatures set in several localities. In Toronto, April was snowier than any of the winter months had been, with spring showers coming down as flurries. In southern Quebec, May temperatures dipped 6 to 12°C below normal. For Easterners, most of the spring was just too long, too cold and too much like the winter they didn't get.

9. Thanksgiving Day Atlantic Weather Bomb

Hurricane Matthew was the costliest tropical storm since Sandy and the first Atlantic Category 5 hurricane in nine years. On October 9, Matthew's core was about 320 km east of Cape Hatteras, North Carolina, yet its "atmospheric river" extended 1,600 km north to Atlantic Canada where it interacted with an intense, slow-moving but rapidly strengthening storm. The hybrid system intensified and began lashing and soaking eastern Nova Scotia and later Newfoundland and Labrador. It was also Nova Scotia's second wettest day ever. Across central Newfoundland, storm rainfall approached 100 mm, but in Gander and Burgeo totals were closer to 150 mm. Loss-estimates from the Insurance Bureau of Canada totalled $103 million, with the vast majority of claims being made in Nova Scotia.

10. Windsor's $100 Million Gusher

A deluge of rain fell in Windsor and Essex County at the end of September. While storm rainfall amounts varied widely, an astonishing 200 mm drenched the Windsor suburbs of Riverside and Tecumseh. Drainage and pumping equipment worked at maximum capacity but couldn't keep up. Flood waters swamped dozens of roads, stranded cars, flooded fields and yards, and filled basements with a metre or more of dirty sewer water. Preliminary insurance-loss estimates exceeded $108 million, with over 6,100 claims, while many additional losses were not covered by insurance.

See http://cmos.ca/site/top_ten for more details.

History of the Canadian Meteorological and Oceanographic Society

Neil J. Campbell, Executive Director, October 1997
updated by Bob Jones, Archivist, September 2016

Introduction

For over 75 years, Canadian meteorologists and oceanographers have assembled to share their research and to communicate with their peers under the umbrellas of several professional societies. In 1967, the Canadian Meteorological Society (CMS) was formed and, beginning in 1975, CMS became CMOS when oceanographers were included. This History documents the establishment and growth of CMOS (including its predecessor societies). It shows the contribution of CMOS to the development of highly qualified researchers and operational personnel by holding annual congresses for the delivery of papers, posters and oral presentations, and by awarding prizes and scholarships.

Early Days

The Canadian Meteorological and Oceanographic Society has a dual history. The meteorological side of the Society traces its roots back to 1939 when a charter was obtained from the Royal Meteorological Society (RMS) to establish a Canadian Branch. The oceanographic component of the Society, on the other hand, had no previous organizational background.

At a meeting of some 33 Canadian members of the Royal Meteorological Society (RMetS) in February 1940, a petition was drawn up requesting the RMetS to recognize a Canadian Branch of the Society. The formal announcement of the foundation of the Canadian Branch was made at a joint meeting of the RMetS and the American Meteorological Society (AMS). The Executive of the day kept no records during the war but it continued in existence. Membership grew from 60 members in 1942 to 110 at the end of the war. By 1949, the number had grown to 200 members and the Branch was well positioned for an even greater expansion in membership and activities later in the post-war years.

In 1953, the Toronto Meteorological Conference was organized by the Branch and this Conference is now considered as the turning point for the organization. It was well-attended and brought together outstanding personalities from the RMetS and the AMS, and such figures as J. Bjerknes and H.U. Sverdrup from Norway. In the same year, the Montreal Centre was organized and took on the responsibilities of providing the Branch Executive. The Montreal Centre inaugurated the annual meteorological congresses and, over the next six years, congresses were held every spring usually in conjunction with the Royal Society of Canada and the other Learned Societies.

The Montreal Centre also launched the forerunner of the journal *Atmosphere*. Initially it was called the *Bulletin of Canadian Meteorology* with the expectation of carrying popular scientific papers and other subjects. As interest grew in the meteorological sciences, Branch centres were soon established by 1961 in Winnipeg and Toronto. The first issue of *Atmosphere* appeared in March 1963. The Vancouver (British Columbia Centre), Halifax and Alberta (Edmonton) Centres were created in 1965, and the Ottawa Centre in 1966.

The idea of separating from the RMetS and establishing an independent Society had been talked about during the 1950s. Both sides complained about the other and finally the question was discussed at the 1964 and 1965 Branch congresses. The formal decision was taken at the seventh and last congress of the Canadian Branch in 1966 at the University of Sherbrooke in the presence and with the full concurrence of the president of the RMetS, who had been invited to participate in this historic meeting by the Canadian Branch. The Canadian Meteorological Society (CMS) came into being on January 1, 1967 and the first congress under the name of the new Society was held at Carleton University in June of that year.

Photo of First CMS congress held at Carleton University, Ottawa, May 24-26, 1967. Photos from later CMOS congresses

First Prizes and Awards in Meteorology

The *President's Prize* is awarded to a Society member (or members) for a recent paper or book of special merit in the fields of meteorology and has been presented since 1967. The *Andrew Thomson Prize in Applied Meteorology* is awarded to a Society member (or members) for an outstanding contribution to the application of meteorology in Canada. This award has been in existence since 1966 and was first presented in the spring of 1967 during the inaugural Congress of the Canadian Meteorological Society. In 1975, the *Rube Hornstein Prize in Operational Meteorology* was added to recognize outstanding meteorological service in a non-research capacity. In 1998, a medal was cast to honour Rube and the Prize was renamed to a medal.

Oceanography Added

Oceanographers had no formal affiliation with a society in Canada. It was not until the late 1950s that a major expansion took place in ocean sciences, not only by the federal government but also by newly-created teaching and research centres of several universities. Oceanographers were keenly aware of the need to create a forum for the presentation of Canadian oceanographic papers. Initially the gap was filled by the Canadian Committee on Oceanography which organized scientific sessions with its annual meetings. However, it did not follow through with a long-term symposium structure.

As Canada became involved in global meteorological and oceanographic programs and experiments such as the Global Atmospheric Research Programme (GARP), its Barbados Oceanographic and Meteorological Experiment of 1969, and the GARP Atlantic Tropical Experiment (GATE) of 1974, the scientists involved found themselves working on, and concerned about, similar atmospheric and oceanic modelling problems. The advantages of bringing the two scientific communities together were obvious to some. As a consequence, talks were held in 1974 with members of the CMS Scientific Committee to consider expanding the role and membership of the Society.

Subsequently, the President of CMS invited oceanographers to join the Society and organize an oceanographic program for the 9th congress in 1975. The theme of the congress was *The Role of the Pacific Ocean in the Climate of North America*. Oceanographers became part of the Society in 1977 at which time the name of the Canadian Meteorological Society was changed to the Canadian Meteorological and Oceanographic Society and that of the journal, *Atmosphere*, was changed to *Atmosphere-Ocean*. It was also agreed that oceanographers could be eligible for the *President's Prize* and graduate student prizes. The *Rube Hornstein Medal in Operational Meteorology* and the *Andrew Thomson Prize in Applied Meteorology* remained exclusively meteorological. The *François J. Saucier Prize in Applied Oceanography* is awarded to a Society member (or members) for an outstanding contribution to the application of oceanography in Canada. First awarded in 1982, this is the longest standing Society award specific to oceanography. From 1982 until 2008, the prize was known as the *CMOS Prize in Applied Oceanography.* In 2009, it was renamed the *François J. Saucier Prize in Applied Oceanography* in memory of member Dr. Saucier who died that year. The *J.P. Tully Medal in Oceanography* was introduced by the Society in 1983.

Non-Profit Status

Any profits earned by the organization are used to promote the advancement of meteorology and oceanography. Amendments were made to the Constitution to reflect the combined interests of meteorologists and oceanographers which paved the way for the Society to become incorporated as a non-profit organization under the Canada Business Corporation Act on August 28, 1984. In the event of the dissolution or winding up of the Society, all its remaining assets, after payment of liabilities, shall be distributed to one or more organizations in Canada having cognate or similar interests.

CMOS is a registered charity and able to issue receipts for donations made to the Society. There are several ways for CMOS Members to make charitable donations to CMOS and receive a consequent tax receipt. Annual donations are the main source of revenue for scholarships, student awards, student science fair adjudications, and Society development funds. As well, one-time substantial Donations and Estate Bequests are encouraged. Member donations are also gratefully accepted. Each year since 2004, CMOS has published in its Annual Review the names of its donors in four categories: Benefactors, Patrons, Sponsors, and Donors.

Governance and Structure

From the very beginning, members of the Society shared the responsibilities of serving in various executive capacities including the organization of congresses and editorship of its publications. The Society is served by a Council, an Executive, a Scientific Committee, an Accreditation Committee, a Broadcaster Endorsement Committee, a Nominating Committee, a Prizes and Awards Committee, and an Education Committee for Meteorology. Membership in 2016 is about 800 spread across Canada with members normally being associated with a Centre.

50th Anniversary: History of CMOS

In 1983, the Society appointed Uri Schwarz as its first Executive Director, a position which is still retained by the Society. Uri contributed significantly to improving the administration of CMOS business affairs. Uri was replaced by Neil Campbell in 1994 and Uri continued working in the CMOS Office as *Executive Director Emeritus*. After her retirement from the Meteorological Service of Canada (MSC) in 1993, Dorothy Neale worked as a volunteer for two decades in the CMOS Office as Executive Secretary, helping especially with her editing expertise in publications and Society documents. While he was Executive Director, Neil Campbell made many innovations and strengthened the Society awards programs. In 2004, Neil was followed by Ian Rutherford who served until 2014. Ian was also active before then, especially in computerization and in modernizing many aspects of the Society.

Before 1982, the University of Toronto Press was contracted to handle both membership lists and subscriptions to publications. In 1983, a formal agreement was signed with the Canadian Association of Physicists (CAP) in Ottawa to provide CMOS with a complete administrative service for subscriptions, membership, mailings, etc., and the first computerized database was installed at CAP. Software difficulties at CAP in 1987 resulted in a contract (from 1988 to 1994) to handle day-to-day CMOS business with *Membership List Management Services (MLMS)* from Newmarket ON, managed by CMOS member, Carr McLeod. In 1994, the business affairs of the Society were returned to CAP. CMOS finally started to administer its own affairs in 2003 from office space in Department of Fisheries and Oceans buildings and began using a dedicated database and association management software which could handle membership, subscriptions, committees, and congress abstracts and registrations.

In the 2000s, the names of two Society committees changed. The Education Committee for Meteorology became the School and Public Education Committee, and the Broadcaster Endorsement Committee became the Weathercaster Endorsement Committee. The following new permanent committees were formed: Advisory Committee for *Atmosphere-Ocean*; Audit Committee; Centre Executive Committee; External Relations Committee; Fellows Committee; Finance and Investment Committee; Membership Committee; Private Sector Committee; and Publications Committee.

From 1982 to 1986, a short-lived Schwarzwald Chapter existed in Lahr Germany. The Kelowna Chapter was formed in 1995, and renamed BC Interior Centre in 2003. In the same year, the BC Centres were reorganized into a Vancouver Island Centre, a Lower Mainland Centre and an Interior Centre (in 2014, BC Interior became BC Interior and Yukon Centre). In 2004, Chapters of CMOS were eliminated because the only difference from Centres was the minimum number of members, and there was confusion between the names. Since 2004, only four members are required to form a Centre.

Publications

When oceanography was added in the Society, *Atmosphere-Ocean* and the *Newsletter* (now the *CMOS Bulletin*) were well developed. Two more publications, originated by others, were added in the early 1980s. In 1983, the Society took over the *Climatological Bulletin*, a journal focused on climate and founded at McGill University in 1967. The *Climatological Bulletin* was published by CMOS for the next ten years until it was merged with the *CMOS Bulletin* in 1994. *Chinook* was a popular weather review magazine first published in 1978 by Michael Newark. CMOS became responsible for *Chinook* in 1984 but was unable to sustain it and *Chinook* was discontinued in 1989.

Paul-André Bolduc, editor of the CMOS Bulletin SCMO from 1996 to mid-2016, has guided the Bulletin from a printed newsletter to a fully digital colour publication, while editing and accepting articles with high accuracy and wide interest. In 2010, the commercial publishing and marketing of *Atmosphere-Ocean* was transferred to *Taylor and Francis*, a large UK journal publisher. CMOS retains full editing and ownership of its flagship journal. *Atmosphere-Ocean* has improved its visibility, recognition, and has published increased numbers of papers and special issues. This was achieved with help from Richard Asselin, Director of Publications from 1996 to 2014, Sheila Bourque, Technical Editor since 1995, and from strong editorial teams.

Logos

The CMOS logo was originally a snowflake with the name of the Canadian Meteorological Society and later the Canadian Meteorological and Oceanographic Society. The present logo, adopted in 1986, symbolizes its meteorological background with diagonal lines depicting rain, and blue waves representing the ocean interests of the Society.

Digital Era

As the millennium approached, CMOS moved with the rest of the world to increase computerization and electronic communication. In 1996, a fledgling web site was started, using DFO servers. In 1998, Bob Jones took over management of the web site and brought it to a high standard of timely and comprehensive coverage, adding such elements as a photo archive of meteorological and oceanographic people and activities. Within two years, the domains ***cmos.ca*** and ***scmo.ca*** were registered and generic email addresses were established. By 2000, all the Society's business affairs, especially publications, began moving to electronic handling.

In 2003, the first (*Amsoft*/Minasu) database and our own servers were acquired and overseen by Ian Rutherford after he had replaced Neil Campbell as Executive Director. During the next ten years, Ian was ably assisted by Richard Asselin who modernized our publications. Ian and Richard brought valuable management expertise to CMOS during this period. Neil Campbell remained active as Executive Director Emeritus, contributing guidance from his extensive corporate memory and strong support of the awards programs.

Today everything is digital, but *Atmosphere-Ocean* and the *Bulletin* are still printed in hard copy. All papers published in *A-O*, *Atmosphere*, *Climatological Bulletin, Canadian Branch of the Royal Meteorological Society* and *Chinook* were digitized and made available to members and others. In 2014, a next generation database (*in1touch*/OlaTec) was implemented, integrating congress arrangements, membership renewals and a modernized web site which allows interactive postings by Centres and members.

Additional Prizes and Awards

More prizes and awards were added. In 1999, the *Tertia M.C. Hughes Memorial Graduate Student Prizes in Meteorology and Oceanography* were inaugurated thanks to fund-raising efforts by Andrew Weaver. The prizes were in memory of Tertia Hughes, a previous CMOS graduate student prizewinner and very promising researcher, who passed away shortly after finishing her Ph.D. In 2003, *The Roger Daley Postdoctoral Publication Award* was established. The *Neil J. Campbell Medal for Exceptional Volunteer Service* was created in 2004 and was presented by Neil for the next several years. In 2008, the Tertia Hughes prizes replaced the Society's *Graduate Student Prizes* which dated from 1967. The *CMOS Prize in Applied Oceanography,* which was started in the early 1980s, was renamed in 2009 as the *François J. Saucier Prize in Applied Oceanography* in memory of François Saucier, a former winner and professor at the University of Quebec at Rimouski (UQAR). CMOS has always supported students in our disciplines. The new millennium brought new CMOS student scholarships, some in collaboration with supporters such as Weather Research House, the Natural Sciences and Engineering Research Council of Canada (NSERC) and The Weather Network. In 2011, a new scholarship, *The Daniel G. Wright Undergraduate Scholarship,* was created to support students intending to study Oceanography. In 2012, Denis Bourque became the first Awards Co-ordinator to handle added work related to the increased number of awards and scholarships. Denis manages nomination calls and presentations at congresses, while the long-standing Prizes and Awards Committee and the Scientific Committee continue to select annual winners.

Like other established societies such as RMetS and AMS, CMOS began a Fellows program in 1999. A “Fellow" is a member who has provided exceptional service and support to the Society, and/or who has made outstanding contributions to the scientific, professional, educational, forecasting or broadcasting fields in atmospheric or ocean sciences in Canada. So far, the new millennium has seen 34 CMOS Fellows announced. Their achievements and year of naming are published on the CMOS web site. In 1999, a 25-year membership pin was inaugurated with 75 members now confirmed.

CMOS (and formerly CMS for meteorology) usually hosts the presentation of two Canadian government major achievement awards in our disciplines at a special luncheon during congresses. The *Patterson Medal,* for distinguished service in meteorology, has been presented annually since 1961 by the Transport and Environment Departments. In 2005, the Department of Fisheries and Oceans inaugurated a similar award, the *Parsons Medal*, which is given for outstanding lifetime or a special achievement in ocean sciences. Honour Rolls of recipients of these medals are on the CMOS web site and winners are usually prominent CMOS members.

Congresses

Following the first congress in 1967, annual congresses were held in all parts of Canada, sometimes involving other societies or organizations. Venues were usually on university campuses in late spring after the students had departed. The most recent congress held at a university was in 2000 at the University of Victoria. Thereafter, Local Arrangements Committees (LACs) preferred to book delegate rooms, catering and conference services from local hotels. The 2003 Ottawa congress was the last one in which Local Arrangements and Scientific Committees did virtually everything. In following years, the recurring parts of congress arrangements, especially registration, session scheduling, abstracts, web sites and exhibits were handled by the CMOS Office using the office databases which reduced duplication and eased the load on LACs. About 110 delegates attended the first

CMS Congress in 1967. Annual congress attendance more than doubled in the next two decades and reached average numbers of about 500 by the millennium. Congresses were increasingly held jointly with other societies and after 2000, attendance occasionally exceeded 700. The joint CGU / CMOS Ottawa Congress in 2010 attracted 1000 delegates. In the past two decades, these larger congresses are now the principal source of revenue for the Society, eclipsing membership fees, costs of publications and other revenue sources.

Tour Speakers

In 1969, the Society began a lecture tour (later called the Tour Speaker program) under which chosen speakers would visit most Centres and Chapters, giving a talk in their areas of expertise. As this program continued, travel support was obtained from the federal departments supporting CM(O)S. The Tour Speaker program has continued with few interruptions and has been a valuable contribution to the meetings scheduled across the country.

CFCAS and Climate Change

Late in 1999, CMOS accepted a request from the federal government to set up a Canadian Foundation for Climate and Atmospheric Sciences (CFCAS). In the budget for 2000-2001, the Minister of Finance announced a grant of $60M to CFCAS to fund research in climate and atmospheric sciences. Members of CMOS Council were designated members of the Foundation and approved the governance of the Foundation. In 2003, a further $50M was added to the Foundation and, during the 12 years it existed, CFCAS was able to provide $118M in research funding. Interest from invested funds covered administration of the grants and enabled the awarding of additional funds. The CFCAS, which was converted in 2011 into the Canadian Climate Forum, was guided by long-time CMOS member and past president, Gordon McBean, and it stands as one of the major achievements of CMOS in its history.

The Scientific Committee issued consistent statements on climate change in 2002, 2003, 2007, 2013 (including a supplement on the oceans) and 2014. These statements were independent of the CFCAS effort but underscored the urgency of supporting climate change research.

SCOR and ECOR

In 1999, CMOS became Secretariat for two Canadian National Committees - SCOR (Scientific Committee on Oceanic Research of the International Council for Science) and ECOR (Engineering Committee on Oceanic Resources). The Department of Fisheries and Oceans provided funding to CMOS for this. The CNC/SCOR Secretariat has since successfully functioned under CMOS and has grown to encompass much Canadian ocean science activity. Since 2003 it has produced an electronic publication, the *Canadian Ocean Science Newsletter (COSN)* that is hosted on the CMOS web site. It runs a tour speaker series to provide opportunities for interaction and collaboration between researchers on both coasts. CNC-SCOR is also active internationally with its parent body, SCOR.

Unfortunately, the members of CNC/ECOR felt that Canadian ocean engineering programs might be better served elsewhere, so CNC/ECOR was dissolved in 2006.

Support to Teachers and Students

During the first decade of the new millennium, CMOS support to pre-college teachers was strengthened. Since about 2000, congresses have usually hosted “Teachers’ Days” as part of the week’s program. Teachers are chosen annually to attend *Project Atmosphere* (run by the American Meteorological Society) and *Project Maury* (run by the US Navy and AMS).

Student outreach has become an important part of CMOS. In the mid 1990s, a program was started to help students with travel costs to attend congresses. Students who receive a travel bursary are required to present a scientific paper or poster. Posters have become an integral part of the science presented at modern congresses. To recognize this, the Campbell Scientific Corporation, the largest corporate supporter of CMOS, established its *Campbell Scientific Best Poster Award* in 2002. In 2011, two more poster awards were established. One was *ASL Environmental Sciences Best Student Poster Prize in Oceanography (*leaving the meteorological area to Campbell Scientific) and the other was from CMOS for best poster in any subject.

Services by Private (non-governmental) Industry

Following a request from MSC, CMOS began an initiative to strengthen the meteorological industry. This culminated with the CMOS publication *A Meteorological Industry Strategy for Canada* in November 2001. A list of private sector companies that could provide meteorological (and oceanographic) services was created. During the following decade, aided by the Private Sector Committee, this list grew and referrals increased for services by these companies. In 2008, also led by the Private Sector Committee, CMOS convinced MSC to make real time meteorological and climate data open access. This was of great benefit to public and private researchers, and companies providing specialized services. A CMOS referral service continues today (2016), a legacy of this initiative.

Partnerships

Recent history records many partnership arrangements with CMOS. Notable among these are the RMetS (original founder of CMS) and the AMS for which reciprocal fee discounts have been negotiated for joint memberships. Similar fee discounts have also been set up the Canadian Geophysical Union (CGU). Beginning with the 2007 St. John's congress, successful joint congresses with CGU started. CGU is now a regular congress partner every few years. Elements of AMS also participate regularly in joint congresses.

In 2013, following new legislation for non-profit organizations, the Constitution underwent a major rewrite. The new rules were simplified and renamed the *By-Laws and Appendices.* The major change was to remove Centre Chairpersons from the governing Council. Their removal was necessary because all Councillors are required to be elected by the members and their total number is limited. The new By-Laws were approved at the 2014 AGM and published in 2015.

Notes: The History of CMOS (up to 1997) is based on a series of articles written by Morley K. Thomas, published in the February, April, October and December 1994 issues of the *CMOS Bulletin SCMO*. The section covering the role played by the oceanographers in joining the Society was published by Dr. Cedric Mann in the February 1995 issue of the *CMOS Bulletin SCMO*. This document, updating events after 1997, was created by the CMOS Archivist who was assisted by a team of past-presidents, executives and long-time members.

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Historique de la société canadienne de météorologie et d'océanographie

Neil J. Campbell, Executive Director, October 1997
Bob Jones, Archivist, September 2016

Introduction

Depuis plus de 75 ans, les météorologistes et les océanographes canadiens se réunissent pour partager leurs recherches et communiquer avec leurs pairs sous l'égide de diverses sociétés professionnelles. En 1967 fut créée la Société de météorologie du Canada (SMC). En 1975, la SMC se transforma en SCMO, quand les océanographes entrèrent au sein de la Société. La présente chronologie des événements retrace la fondation et la croissance de la SCMO, y compris de ses sociétés précédentes. Elle montre la contribution de la SCMO au parcours de chercheurs hautement qualifiés et de spécialistes opérationnels, qui profitent des congrès annuels pour présenter leurs articles, leurs affiches et leurs exposés oraux et qui reçoivent des prix et des bourses d'études grâce à la Société.

Les débuts

La Société canadienne de météorologie et d'océanographie à une double histoire. La composante « météorologique » de la Société remonte à 1939, quand la Royal Meteorological Society (RMS) lui octroya une charte pour fonder une section canadienne. La composante « océanographique » de la Société, en revanche, n'avait aucun antécédent en tant qu'organisation.

Lors d'une réunion de quelque 33 membres de la Royal Meteorological Society, en février 1940, une pétition demandant à celle-ci de reconnaître la section canadienne de la Société fut déposée. La fondation de la section canadienne fut annoncée officiellement lors d'une réunion conjointe de la Royal Meteorological Society et de l'American Meteorological Society (AMS). Durant la guerre, l'exécutif de l'époque ne consigna aucune information, mais la section existait toujours. Le nombre de membres passa de 60 en 1942 à 110 à la fin de la guerre. Dès 1949, le nombre de membres atteignait 200. La section canadienne se trouvait bien placée pour faire croître ses rangs et ses activités, au fil des années d'après-guerre.

En 1953, elle organisa le Congrès météorologique de Toronto. Cet événement est maintenant considéré comme un moment crucial de l'organisme. Le congrès avait joui d'une bonne participation et avait attiré des sommités de la RMS et de l'AMS, ainsi que d'éminents scientifiques comme J. Bjerknes et H.U. Sverdrup, de la Norvège. Au cours de la même année, le centre de Montréal fut fondé et assuma la responsabilité de comité exécutif de la section. Le centre de Montréal inaugura les congrès annuels météorologiques. Au cours des six années subséquentes, les congrès eurent lieu chaque printemps et, en général, conjointement avec la Société royale du Canada et d'autres sociétés savantes.

Le centre de Montréal lança également le prédécesseur de la revue *Atmosphere*. Celui-ci s'appelait le *Bulletin of Canadian Meteorology* et contenait des articles scientifiques populaires et des articles sur des sujets généraux. Comme l'intérêt pour les sciences météorologiques grandissait, des centres virent le jour à Winnipeg et à

Toronto, dès 1961. Le premier numéro d'*Atmosphere* parut en mars 1963. Les centres de Vancouver (centre de la Colombie-Britannique), de Halifax et de l'Alberta (Edmonton) furent créés en 1965, et le centre d'Ottawa, en 1966.

Photo du deuxième congrès de la SMC, tenu à l'université de Calgary, en mai 1968. Photos des congrès de la SCMO subséquents

L'idée de se séparer de la Royal Meteorological Society et de fonder une société indépendante fut discutée durant les années 1950. Les parties se plaignaient l'une de l'autre et finalement la question fut soulevée aux congrès de 1964 et de 1965. La décision officielle fut prise lors du septième et dernier congrès de la section canadienne, en 1966, à l'Université de Sherbrooke, en présence et avec le plein accord du président de la Royal Meteorological Society, que les membres canadiens avaient invité à participer à cette rencontre historique. La Société de météorologie du Canada (SMC) fut fondée le 1er janvier 1967. Le premier congrès sous l'appellation de la nouvelle société eut lieu à l'université Carleton, en juin de la même année.

Premiers prix et distinctions en météorologie

Le *Prix du président* est décerné à un ou plusieurs membres de la Société, afin de souligner la valeur particulière d'un article ou d'un livre récents, portant sur la météorologie. Il est présenté depuis 1967. Le prix *Andrew-Thomson en météorologie appliquée* est décerné à un ou plusieurs membres de la Société pour un travail exceptionnel dans le domaine de la météorologie appliquée au Canada. Ce prix existe depuis 1966 et fut présenté pour la première fois au printemps 1967, lors du congrès inaugural de la Société de météorologie du Canada. Le *prix Rube-Hornstein de météorologie opérationnelle* fut ajouté en 1975, pour souligner un travail exceptionnel relatif aux services météorologiques, en dehors de la recherche. En 1998, une médaille fut créée en l'honneur de Rube et le prix fut renommé « médaille » Rube-Hornstein.

Arrivée des océanographes

Les océanographes n'étaient pas regroupés en une organisation formelle au Canada. Ce n'est qu'à la fin des années 1950 que les sciences océaniques connurent un essor important, non seulement sous l'initiative du gouvernement fédéral, mais également grâce à de nouveaux centres de recherche et d'enseignement que mirent en place de nombreuses universités. Les océanographes étaient très conscients de la nécessité de se doter d'une tribune pour la présentation de recherches canadiennes dans leur domaine. Au début, le Comité canadien d'océanographie, qui organisait des séances scientifiques lors de ses réunions annuelles, combla le vide. Toutefois, une structure durable, sous forme de colloques, n'en émergea pas.

Tandis que le Canada participait de plus en plus aux expériences et aux programmes météorologiques et océanographiques mondiaux, comme le Global Atmospheric Research Programme (GARP), son Barbados Oceanographic and Meteorological Experiment de 1969, et le GARP Atlantic Tropical Experiment (GATE) de 1974, les scientifiques participants comprirent que leurs travaux en météorologie et en océanographie, ainsi que leurs préoccupations, concernaient des problèmes de modélisation similaires. Pour certains, les avantages de regrouper ces deux communautés scientifiques sautaient aux yeux. Conséquemment, en 1974, des discussions avec des membres du comité scientifique de la SMC eurent lieu, afin de prendre en considération la possibilité d'étendre le rôle et le nombre de membres de la Société.

Plus tard, le président de la SMC invita les océanographes à se joindre à l'organisation et à proposer un programme portant sur l'océanographie pour le 9^{e} Congrès, en 1975. Celui-ci avait pour thème « Le rôle de l'océan Pacifique dans le système climatique nord-américain ». Les océanographes se joignirent à la Société en 1977 et le nom de la Société météorologique du Canada devint « Société canadienne de météorologie et d'océanographie ». En même temps, la revue *Atmosphere* prit le nom d'*Atmosphere-Ocean*. Dans la foulée, il fut convenu que les océanographes seraient admissibles au *Prix du président* et aux prix pour les étudiants des cycles supérieurs. La *médaille Rube-Hornstein en météorologie opérationnelle* et le *prix Andrew-Thomson en météorologie appliquée* restent toutefois réservés à la météorologie. Le *prix François-J.-Saucier en océanographie appliquée* est décerné à un ou plusieurs membres de la Société pour un travail exceptionnel dans le domaine de l'océanographie appliquée au Canada. Octroyé pour la première fois en 1982, ce prix est la plus ancienne récompense de la Société réservée aux océanographes. De 1982 à 2008, il était connu sous le nom de *prix de la SCMO en océanographie appliquée.* En 2009, il fut renommé *prix François-J.-Saucier en océanographie appliquée*, en mémoire de F.-J. Saucier (Ph. D.), membre de la SCMO, décédé en 2008. La Société instaura en 1983 la *médaille J.-P.-Tully en océanographie*.

Organisme sans but lucratif

Tout profit que gagne l'organisation sert à promouvoir l'avancement de la météorologie et de l'océanographie. Des modifications furent apportées à la constitution afin de refléter les champs d'intérêt combinés des météorologistes et des océanographes. Ces démarches pavèrent la voie pour que la Société se constitue en organisme sans but lucratif, ce qui fut réalisé le 28 août 1984, en vertu de la *Loi sur les sociétés par actions*. En cas de dissolution ou de liquidation de la Société, tous les actifs restant après le paiement des créances, seront distribués à un ou des organismes canadiens qui poursuivent des champs d'intérêt connexes ou similaires.

La SCMO est un organisme de bienfaisance enregistré et peut délivrer des reçus en contrepartie de dons. Il existe plusieurs façons pour les membres de la SCMO de verser un don à la Société et d'obtenir un reçu pour déduction d'impôts. Les dons annuels sont la principale source de revenus pour les bourses d'études, les récompenses aux étudiants, les prix du jury aux élèves des expo-sciences et le fonds de développement de la Société. Les dons uniques et les legs substantiels sont aussi encouragés. Les dons des membres sont acceptés avec grand plaisir. Chaque année, depuis 2004, la SCMO publie dans sa Revue annuelle le nom des donateurs selon quatre catégories : bienfaiteur, mécène, parrain et donateur.

Gouvernance et structure

Depuis le tout début, les membres se partagent les responsabilités au sein de la direction de la SCMO, y compris celles de l'organisation du congrès et de la rédaction des publications. La Société comprend un conseil d'administration, un comité exécutif, un comité scientifique, un comité d'accréditation, un comité d'agrément des présentateurs météo, un comité des nominations, un comité des prix et récompenses et un comité d'éducation pour la météorologie. Le nombre de membres atteignait environ 800, en 2016, et ceux-ci venaient de partout au Canada; les membres étant normalement associés à un centre local.

En 1983, la Société nomma Uri Schwarz comme premier directeur général, un poste qui existe toujours au sein de la Société. Uri contribua considérablement à l'amélioration de l'administration des affaires de la SCMO. Neil Campbell remplaça Uri en 1994, tandis que ce dernier continuait à travailler auprès de la SCMO en tant que *directeur général émérite*. Après avoir pris sa retraite du Service météorologique du Canada (SMC), en 1993, Dorothy Neale travailla comme secrétaire bénévole pendant 20 ans au sein du bureau de la SCMO. Elle fit profiter de son expertise en édition les publications et les documents de la Société. Durant ses années en tant que directeur général, Neil Campbell apporta plusieurs innovations et renforça les programmes de récompenses de la Société. En 2004, Ian Rutherford remplaça Neil et servit la SCMO jusqu'en 2014. Ian s'activait déjà au sein de l'organisme, notamment en ce qui concerne l'informatisation et la modernisation de plusieurs aspects de la Société.

Avant 1982, la University of Toronto Press était liée par contrat et s'occupait de la liste des membres et des abonnements aux publications. En 1983, une entente officielle fut signée avec l'Association canadienne des physiciens (ACP) à Ottawa. Celle-ci fournissait à la SCMO des services administratifs complets pour les abonnements, l'adhésion, la correspondance, etc. La première base de données informatisée fut installée dans le bureau de l'ACP. Des problèmes de logiciel à l'ACP, en 1987, firent en sorte que la SCMO donna le contrat (1988 à 1994) de l'administration de ses affaires courantes à *Membership List Management Services (MLMS)* de Newmarket (ON), que gérait Carr McLeod, un membre de la SCMO. En 1994, l'ACP reprit l'administration des affaires de la SCMO. Celle-ci commença finalement à gérer ses propres affaires en 2003, à partir de locaux prêtés par le ministère des Pêches et des Océans. Elle commença aussi à utiliser un logiciel de base de données et d'administration d'association, qui permettait la gestion des adhésions, des abonnements, des comités et des congrès (résumés et inscriptions).

Dans les années 2000, le nom de deux comités de la SCMO changea. Le comité d'éducation pour la météorologie devint le comité d'éducation publique et scolaire et le comité d'agrément des présentateurs à la télévision et à la radio devint le comité d'agrément des présentateurs météo. Les nouveaux comités permanents suivants furent formés : le comité consultatif pour *Atmosphere-Ocean*; le comité de vérification des comptes; le comité exécutif pour les centres; le comité des relations extérieures; le comité des membres émérites; le comité des finances et des investissements; le comité d'adhésion; le comité du secteur privé et le comité des publications.

De 1982 à 1986, le chapitre de Schwarzwald était actif à Lahr en Allemagne. Le chapitre de Kelowna fut formé en 1995 et renommé le centre BC Interior, en 2003. Cette même année, les centres de la Colombie-Britannique se réorganisèrent pour former : le centre de l'Île de Vancouver, le centre Lower Mainland et le centre BC Interior (en 2014, le centre BC Interior est devenu le centre BC Interior et Yukon). En 2004, les « chapitres » de la SCMO furent abolis. Tout ce qui les distinguait des centres était le nombre minimal de membres, et ces deux appellations portaient à confusion. Depuis 2004, seulement quatre membres sont nécessaires pour former un centre.

Publications

Quand l'océanographie s'ajouta à la Société, *Atmosphere-Ocean* et la lettre de *nouvelles* (maintenant le *Bulletin de la SCMO*) étaient déjà bien développés. Deux autres publications, qu'avaient créées d'autres organismes, s'ajoutèrent au début des années 1980. En 1983, la Société assuma la publication du *Climatological Bulletin*, une revue portant sur le climat qu'avait démarrée l'Université McGill en 1967. La *SCMO* publia le *Climatological Bulletin* pendant 10 ans, jusqu'à ce que celui-ci soit incorporé au *Bulletin de la SCMO* en 1994. *Chinook* était une revue populaire portant sur la météorologie, qu'avait publiée Michael Newark pour la première fois en 1978. La SCMO publia cette revue à partir de 1984, mais ne put soutenir *Chinook* au-delà de 1989.

Paul-André Bolduc, rédacteur en chef du CMOS Bulletin SCMO de 1996 à 2016, convertit une simple lettre de nouvelles imprimée en une publication en couleur entièrement numérique, tout en éditant et en acceptant des articles de qualité et de grand intérêt. En 2010, la publication commerciale et la mise en marché d'*Atmosphere-Ocean* furent transférées à *Taylor & Francis*, un éditeur britannique de revues de grande envergure. La SCMO garde les droits d'édition et de propriété complets de sa revue phare. *Atmosphere-Ocean* jouit d'une visibilité et d'une notoriété accrues, et il s'y publie de plus en plus d'articles et de numéros spéciaux. Cela grâce au travail de Richard Asselin, directeur des publications de 1996 à 2014, de Sheila Bourque, rédactrice technique depuis 1995 et des équipes éditoriales de haut calibre.

Logos

Le premier logo de la SCMO figurait un flocon de neige accompagné du nom de la Société de météorologie du Canada, puis de celui de la Société canadienne de météorologie et d'océanographie. Le logo actuel, adopté en 1986, symbolise son origine « météorologique » par des diagonales qui représentent la pluie et des vagues bleues qui représentent le volet « océanographique » de la Société.

Ère numérique

Tandis que le nouveau millénaire approchait, la SCMO, à l'instar du reste du monde, s'informatisait et augmentait ses communications électroniques. En 1996, un tout nouveau site Web, hébergé sur les serveurs du MPO, vit le jour. En 1998, Bob Jones se chargea de la gestion du site Web et propulsa celui-ci à un autre niveau, grâce à un contenu utile et complet. Il ajouta des archives photographiques immortalisant les gens et les activités liés à la météorologie et à l'océanographie. Moins de deux ans plus tard, les domaines ***cmos.ca*** et ***scmo.ca*** furent réservés et des adresses de courriel génériques furent créées. Dès 2000, toutes les affaires de la Société, notamment les publications, s'informatisèrent.

En 2003, nous acquîmes notre première base de données (*Amsoft*/Minasu) et nos propres serveurs. Ian Rutherford en prit la charge, en tant que directeur général, après le départ de Neil Campbell. Au cours des dix années suivantes, Ian reçut l'aide de Richard Asselin, qui modernisa nos publications. Durant cette période, Ian et Richard apportèrent à la SCMO une solide expertise de la gestion. Neil Campbell demeura actif en tant que directeur général émérite. Il fit profiter la Société de sa grande mémoire de l'entreprise et de son soutien indéfectible pour les programmes de récompenses.

De nos jours, tout est numérique. Mais *Atmosphere-Ocean* et le *Bulletin* sont aussi offerts en version papier. Tous les articles publiés dans *A-O*, *Atmosphere*, le *Climatological Bulletin* de la section canadienne de la Royal Meteorological Society et *Chinook* furent numérisés et sont mis à disposition des membres et autres. En 2014, nous implantâmes une base de données de dernière génération (*in1touch*/OlaTec). Celle-ci intègre l'organisation des congrès, le renouvellement d'adhésions et un site Web modernisé, qui permet l'affichage de messages interactifs par les centres et les membres.

Prix et distinctions supplémentaires

Des prix et des distinctions s'ajoutèrent. En 1999, les *prix commémoratifs Tertia-M.-C.-Hughes pour les étudiants des cycles supérieurs en météorologie et en océanographie* furent instaurés grâce aux activités de financement d'Andrew Weaver. Les prix sont octroyés en mémoire de Tertia Hughes, une étudiante des cycles supérieurs, lauréate d'un prix de la SCMO et chercheuse très prometteuse, qui est décédée peu après avoir terminé son doctorat. En 2003, le *prix Roger-Daley de publication* postdoctorale vit le jour. La *médaille Neil-J.-Campbell pour service bénévole exceptionnel* fut créée en 2004. Neil présenta lui-même la médaille pendant plusieurs années. En 2008, les prix Tertia-Hughes remplacèrent les *prix de la SCMO pour les étudiants des cycles supérieurs*, qui dataient de 1967. Le *prix de la SCMO en océanographie appliquée*, créé au début des années 1980, fut renommé en 2009 *prix François-J.-Saucier en océanographie appliquée*, en mémoire de François Saucier, un lauréat du prix et professeur à l'Université du Québec à Rimouski (UQAR). La SCMO soutient depuis toujours les étudiants de ses domaines. Le nouveau millénaire amena de nouvelles bourses d'études de la SCMO, certaines en collaboration avec des partenaires comme la Weather Research House, le Conseil de recherches en sciences naturelles et en génie (CRSNG) et MétéoMédia. En 2011, une nouvelle bourse fut créée, la *bourse d'études de* *premier cycle Daniel-G.-Wright*, afin de soutenir les étudiants qui souhaitent étudier l'océanographie. En 2012, Denis Bourque assuma le premier le poste de coordonnateur des récompenses, afin de se charger du travail supplémentaire que demandaient les nouveaux prix et bourses. Denis gère les appels de nominations et la présentation des prix aux congrès, tandis que le comité des prix et des distinctions, qui existe depuis longtemps, et le comité scientifique continuent de sélectionner annuellement les gagnants.

Comme d'autres sociétés telles que la Royal Meteorological Society et l'AMS, la SCMO mit sur pied en 1999 un programme de membre émérite. Le titre de « membre émérite » peut être conféré à un membre qui a servi et soutenu la Société de manière exceptionnelle, ou qui a contribué de façon remarquable aux domaines scientifique, professionnel, éducationnel, médiatique ou de la prévision, relativement aux sciences de l'atmosphère et de l'océan au Canada. Depuis 2000, nous avons annoncé la nomination de 34 membres émérites de la SCMO. Leurs réalisations et l'année de leur nomination figurent sur le site Web de la SCMO. En 1999, nous créâmes une épinglette commémorant 25 années d'adhésion, 75 membres y eurent droit jusqu'à maintenant.

La SCMO (et anciennement la SMC, pour la météorologie) organise habituellement la présentation de deux prix du gouvernement du Canada soulignant des réalisations majeures dans nos domaines. Ces prix sont remis au cours d'un dîner spécial pendant le congrès. Les ministères des Transports et de l'Environnement présentent annuellement depuis 1961 la *médaille Patterson* pour service méritoire en météorologie. En 2005, le ministère des Pêches et des Océans inaugura une récompense semblable, la *médaille Parsons*, qui est octroyée pour souligner l'excellence démontrée au cours de la vie du récipiendaire ou pour une réalisation exceptionnelle en sciences de la mer. Les listes de récipiendaires de ces médailles figurent sur le site Web de la SCMO. Les gagnants sont généralement des membres éminents de la Société.

Les congrès

Après le premier congrès de 1967, les congrès annuels se tinrent partout au Canada, parfois conjointement avec d'autres sociétés ou organismes. Ils se déroulaient généralement sur des campus universitaires, à la fin du printemps, après que les étudiants étaient partis. Le dernier congrès à se tenir dans une université eut lieu en 2000, à l'Université de Victoria. Par la suite, les comités locaux d'organisation préférèrent réserver les chambres des participants, et les services de repas et de congrès auprès d'hôtels locaux. Le Congrès d'Ottawa en 2003 fut le dernier pour lequel le comité local d'organisation et le comité scientifique se chargèrent de toute l'organisation. Les années suivantes, le bureau de la SCMO s'occupa des aspects récurrents des congrès, notamment l'inscription, la programmation des séances, les résumés, le site Web et les expositions, et ce, à l'aide de ses bases de données. Ce qui réduit le chevauchement et allégea la charge des comités locaux d'organisation. Environ 110 personnes participèrent au premier congrès de la SMC en 1967. La participation aux congrès annuels avait plus que doublé au cours des vingt années subséquentes. Dès le passage à l'an 2000, les congrès comptaient environ 500 participants par année. Ils se tinrent de plus en plus souvent conjointement avec d'autres sociétés et, après 2000, le nombre de participants atteignait parfois 700. Le congrès conjoint UGC-SCMO d'Ottawa en 2010 attira 1000 personnes. Au cours des vingt dernières années, ces grands congrès devinrent la principale source de revenus de la Société, éclipsant ainsi les frais d'adhésion, les frais de publications et les autres sources de revenus.

Conférenciers itinérants

En 1969, la Société instaura des tournées de conférences (maintenant appelées programme des conférenciers itinérants) durant lesquelles des conférenciers visitaient la plupart des centres et des chapitres, et présentaient des études dans leur domaine d'expertise. Tandis que ce programme se poursuivait, les ministères fédéraux qui soutenaient la SMC/SCMO commencèrent à financer les coûts de voyage. Le programme de conférenciers itinérants se poursuivit avec peu d'interruptions et s'avéra une contribution utile aux réunions organisées partout au Canada.

La FCSCA et les changements climatiques

À la fin de 1999, la SCMO accepta une demande du gouvernement fédéral concernant la création de la Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA). Dans le budget de 2000-2001, le ministre des Finances annonça une subvention de 60 millions de dollars destinés à la FCSCA, afin de financer la recherche sur le climat et en sciences atmosphériques. Les membres du conseil de la SCMO furent désignés membres de la Fondation et approuvèrent la gouvernance de celle-ci. En 2003, la Fondation se vit octroyer 50 millions de dollars additionnels et, durant ses 12 années d'existence, elle remit 118 millions de dollars en subventions de recherche. Les revenus d'intérêts de placement couvraient les frais d'administration des subventions et permettaient l'octroi de fonds supplémentaires. Gordon McBean, un membre de longue date et ancien président de la SCMO, dirigeait la FCSCA, qui se transforma en 2011 en Forum canadien du climat. Cette fondation s'avéra l'une des réalisations majeures de la SCMO.

Le comité scientifique émit des énoncés sur les changements climatiques en 2002, 2003, 2007, 2013 (incluant un supplément sur les océans) et 2014. Ces énoncés demeuraient indépendants des travaux de la FCSCA, mais renforçaient l'urgence de soutenir la recherche sur les changements climatiques.

SCOR et ECOR

En 1999, la SCMO assuma la fonction de secrétariat pour deux comités nationaux canadiens : l'un rattaché au SCOR (Comité scientifique pour les recherches océaniques du Conseil international pour la science) et l'autre à l'ECOR (Comité de l'ingénierie des ressources océaniques). Le financement de ces comités de la SCMO provenait du ministère des Pêches et des Océans. Le secrétariat du CNC du SCOR fonctionne toujours avec succès sous l'égide de la SCMO et s'est élargi pour intégrer davantage d'activités relatives aux sciences de la mer au Canada. Depuis 2003, il produit une publication électronique, le *Bulletin canadien des sciences de l'océan,* hébergé sur le site Web de la SCMO. Il gère aussi une tournée de conférences, afin de donner l'occasion aux chercheurs de l'est et de l'ouest du Canada d'interagir et de collaborer. Le CNC du SCOR s'active aussi sur la scène internationale au sein même du SCOR. Malheureusement, les membres du CNC de l'ECOR sentirent que les programmes relatifs à l'ingénierie des ressources océaniques seraient mieux servis ailleurs, ainsi le CNC de l'ECOR s'est dissous en 2006.

Soutien aux enseignants et aux étudiants

Au cours des dix premières années du millénaire, le soutien de la SCMO aux enseignants du primaire et du secondaire s'accrut. Depuis environ 2000, le programme de la semaine de congrès comprend une « journée des enseignants ». Des enseignants sont choisis annuellement pour participer au *Projet atmosphère* (que gère l'American Meteorological Society) et au *projet Maury* (que gèrent la US Navy et l'AMS).

La mobilisation des étudiants est maintenant une activité importante de la SCMO. Au milieu des années 1990, nous inaugurâmes un programme d'aide aux étudiants. Ceux-ci reçoivent une subvention pour leur permettre d'assister aux congrès. Les étudiants qui reçoivent cette subvention doivent présenter un article scientifique ou une affiche. La présentation par affiche est maintenant partie intégrante de la science présentée aux congrès modernes. Afin de souligner ce fait, Campbell Scientific, le plus généreux commanditaire commercial de la SCMO, créa en 2002, le *prix Campbell Scientific de la meilleure affiche*. En 2011, deux autres prix relatifs aux affiches virent le jour : le *prix ASL Environmental Sciences pour la meilleure affiche en océanographie par un étudiant* (laissant le domaine de la météorologie à Campbell Scientific) et le *prix de la SCMO pour la meilleure affiche sur n'importe quel sujet*.

Services de l'industrie privée (non gouvernementale)

À la suite d'une demande du Service météorologique du Canada, la SCMO prit sur elle de renforcer l'industrie météorologique. Cette initiative entraîna, en novembre 2001, la publication, par la SCMO, du document *A Meteorological Industry Strategy for Canada*. La Société créa une liste des entreprises du secteur privé qui fournissaient des services météorologiques et océanographiques. Au cours des dix années suivantes, avec l'aide du comité du secteur privé, la liste s'allongea et les recommandations augmentèrent pour les services qu'offraient ces compagnies. En 2008, sous la direction du comité du secteur privé, la SCMO convainquit le Service météorologique du Canada d'ouvrir l'accès aux données météorologiques et climatologiques en temps réel. Cet accès s'avère profitable pour les chercheurs de tous les secteurs et pour les entreprises qui proposent des services spécialisés. Le service de recommandation de la SCMO se poursuit de nos jours (2016), à la suite de cette initiative.

Partenariats

L'histoire récente fait état de plusieurs ententes de partenariats entre la SCMO et d'autres organismes: notamment, la RMS (fondatrice de la SMC) et l'AMS, pour laquelle une réduction réciproque des frais d'adhésion fut négociée pour ceux qui sont membres des deux organismes. Des réductions semblables furent aussi négociées auprès de l'Union géophysique canadienne (UGC). Les congrès conjoints fructueux avec l'UGC se poursuivirent après celui de St. John's, en 2007. L'UGC reste un partenaire de congrès régulier, à intervalle de quelques années. Des délégués de l'AMS participent aussi régulièrement à des congrès conjoints. En 2013, à la suite de la nouvelle loi sur les OSBL, notre constitution fit l'objet de grandes modifications. Les nouvelles règles furent simplifiées et renommées *Règlement et annexes.* Une modification majeure à notre structure fut de retirer du conseil d'administration les présidents des centres. Ce retrait était nécessaire, car ce sont les membres qui doivent élire en totalité un nombre limité de conseillers. Le nouveau règlement fut approuvé lors de l'AGA de 2014 et publié en 2015.

Remarques: L'histoire de la SCMO (jusqu'en 1997) est fondée sur une série d'articles que rédigea Morley K. Thomas et qui parurent dans les numéros de février, d'avril, d'octobre et de décembre 1994 du *CMOS Bulletin SCMO*. La section portant sur le rôle que jouèrent les océanographes lors de leur arrivée au sein de la Société vient d'un texte que publia Cedric Mann (Ph. D.), dans le numéro de février 1995 du *CMOS Bulletin SCMO*. L'archiviste de la SCMO, avec l'aide d'une équipe d'anciens présidents, de dirigeants et de membres de longue date, a créé ce document mettant à jour les événements survenus après 1997.

50th Anniversary: Golden Jubilee Fund

Turning CMOS 50th Anniversary Celebrations into Action

Plans are continuing to develop to celebrate the 50th anniversary of the creation of the Canadian Meteorological Society (CMS) and the 40th anniversary of the addition of the oceanographic disciplines to create the Canadian Meteorological and Oceanographic Society (CMOS). The anniversary date was January 1, 2017, but we will recognize this important milestone many ways over the coming months.

During the last 50 years, CMOS and its members have made invaluable contributions to Canadian and global science. They have improved the safety of Canadians and assisted economic advancement in Canada. To celebrate these achievements, CMOS is planning a series of activities for 2017 including:

- a public webcast by prominent scientists or spokespersons in collaboration with the Canadian Climate Forum, to provide credible scientific information on climate change to Canadians;
- special sessions at the Toronto Congress in June 2017, with invited speakers, international guests and media publicity; and
- a special publication highlighting the best of *Atmosphere-Ocean* over the years, showcasing the "state of the art" of our disciplines.

The Council of CMOS has created the Golden Jubilee Fund for 2016-17 that will provide CMOS with the resources to showcase our rich history and our sciences through these activities. A tax-deductible donation to the Golden Jubilee Fund will offer individuals, organizations and companies the opportunity to support CMOS in our ambition to be more visible as we celebrate our special anniversary.

Please consider making a donation as you renew your membership for 2017. You can donate today in the Member Area of the CMOS web site (preferred method) or by using the DONATE ONLINE NOW button on the CMOS home page (www.cmos.ca). Donations will be accepted any time in the coming year, but your early consideration of this venture is important.

CMOS thanks you for your support. Watch the CMOS Bulletin and CMOS web site for updates on these and other 50th anniversary activities.

Martin Taillefer, CMOS President

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Concrétiser les célébrations du 50e anniversaire de la SCMO

Nous continuons de planifier les célébrations du 50e anniversaire de la fondation de la Société de météorologie du Canada (SMC) et du 40e anniversaire de l'ajout des sciences de la mer, qui mena à la création de la Société canadienne de météorologie et d'océanographie (SCMO). La date exacte de l'anniversaire était le 1er janvier 2017, mais nous soulignerons cet important jalon de plusieurs façons, au fil des mois.

Au cours des 50 dernières années, la SCMO et ses membres ont considérablement contribué aux sciences canadiennes et mondiales. Ils ont renforcé la sécurité des Canadiens et participé à l'avancement économique du pays. Afin de célébrer ces réalisations, la SCMO planifie une série d'activités pour l'année 2017, y compris :

- Un web émission publique mettant en vedette d'éminents scientifiques ou porte-paroles, et ce, en collaboration avec le Forum canadien du climat, afin d'offrir aux Canadiens une information scientifique crédible sur les changements climatiques;
- Des séances spéciales au Congrès de Toronto en juin 2017, comprenant des conférenciers, des invités internationaux et une campagne publicitaire dans les médias;
- Une publication spéciale qui souligne le meilleur d'*Atmosphere-Ocean* et témoigne de la fine pointe de nos domaines.

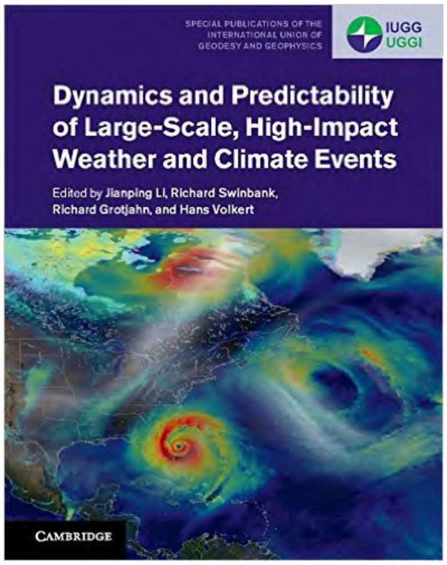
Le conseil de la SCMO a créé le Fonds du jubilé pour l'année 2016-2017, afin de nous fournir les moyens de présenter la riche histoire et les sciences de la Société grâce à ces activités. Un don déductible d'impôts au Fonds du jubilé offrira aux particuliers, aux organisations et aux entreprises l'occasion de soutenir la SCMO dans son désir d'accroître sa visibilité tandis que nous célébrons cet anniversaire spécial.

N'hésitez pas à effectuer un don tandis que vous renouvelez votre adhésion en 2017. Vous pouvez le faire dès aujourd'hui dans l'Espace membres du site Web de la SCMO (méthode préférée), ou en cliquant sur le bouton DON EN LIGNE, sur la page d'accueil de la SCMO (www.scmo.ca). Nous accepterons les dons tout au long de l'année, mais les dons hâtifs s'avéreront les plus utiles.

La SCMO vous remercie de votre soutien. Consultez le *Bulletin* et le site Web de la SCMO pour vous tenir au courant des activités du 50e anniversaire.

Martin Taillefer, Président de la SCMO

Book Review



Dynamics and Predictability of Large-Scale, High-Impact Weather and Climate Events

Jianping Li, Richard Swinbank, Richard Grotjahn, and Hans Volkert, eds.

Cambridge University Press, ISBN 978-1-107-07142-1
2016, hardcover, xiii + 356 pages, $140

Book reviewed by J.J.P. Smith[1]

We are living in the age of weather. Humanity has come to have a greater understanding and social response to weather phenomena, particularly events of a dramatic character now routinely witnessed on a global scale. The past year was replete with them, and some of their names are easily recalled: Hurricane Matthew, Typhoon Lionrock (among others in the eastern Pacific) and Cyclone Winston. Perhaps the most dramatic event was the Fort McMurray wildfire, considered Canada's costliest natural disaster. As this edition of the CMOS *Bulletin* goes to press, the World Meteorological Organization (WMO) will complete its analysis of weather in 2016 and is sure to conclude the year was the hottest on record, with observed new highs in India, Kuwait, Thailand, and South Africa. Interdisciplinary research, meanwhile, has started to draw credible linkages between anthropogenic climate change, severe weather events (and pattern changes) and social consequences including food insecurity and armed conflict. A comprehensive understanding of what makes for large-scale weather events has seemingly never been more needed. This well-written book, *Dynamics and Predictability of Large-Scale, High-Impact Weather and Climate Events*, arrives at an opportune moment.

The book is the fruit of the August 2012 Kunming conference of the International Commission on Dynamical Meteorology (the ICDM), one of the organizations in the constellation of the International Union of Geodosy and Geophysics, and the International Association of Meteorology and Atmospheric Sciences (the IAMAS). *Dynamics and Predictability* stand out among the burgeoning literature, both of popular explanation (such as Adam Sobel's 2014 *Storm Surge: Hurricane Sandy, Our Changing Climate, and Extreme Weather of the Past and Future*) and scholarly-practitioner oriented works (such as the American Meteorological Society's annual *Bulletin* supplement on extreme weather events). The goal of the book's editors and contributors was "not to create a geographical survey of extreme events, but rather to illustrate broader dynamical consequences of such events." 27 chapters by 59 leading authors, including Canada's Francis Zwiers (UVic) and Xuebin Zhang (Environment Canada), are organized into the following six parts:

I. Diagnostics and prediction of high-impact weather;
II. High-impact weather in mid latitudes;
III. Tropical cyclones;
IV. Heat waves and cold-air outbreaks;
V. Ocean connections; and
VI. Asian monsoons.

Part I serves as both topic summary and a useful refresher of atmospheric physics, thermodynamics and statistical theory of extreme event probability. Zhang and Zwiers' Chapter 4, "Observed and projected changes in temperature and precipitation extremes" is a fine discussion of trends "attributable to human influence … at the global scale". In five chapters Part II ably canvasses weather phenomena of immediate interest to Canadians, including the influence of the jet stream, and how the North Atlantic and Arctic Oscillations influence climate variability. Oxford University's Tim Woolings, a frequent contributor to the journal *Climate Dynamics*, features here with an interesting discussion of storm track evaluation methodology (Chapter 8). (What causes changes to storm tracks is of interests to meteorologists contending with recent exceptional wind speed events on the British Columbia coast.)

Part III marks a turn to the tropical, with five chapters on the ever-fascinating subject of cyclone prediction. If one is searching for a collective current reference on the life-cycle of Atlantic and Pacific cyclones, it is here. The

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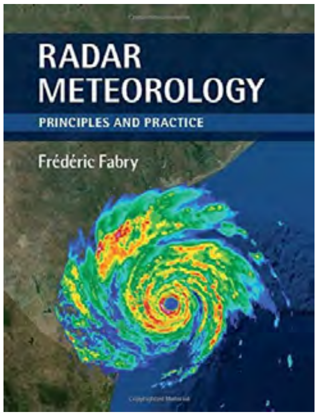
[1] *McGill and Carleton Universities.*

chapters are surprisingly devoid of quantitative calculations, the focus instead being on a critical discussion of predictive theory and the limits of present forecasting models. Predictably, 2012's Hurricane Sandy merits discussion in Chapter 11, with Tom Beers and Oscar Alves in Chapter 14 giving an insightful explanation of Australia's "Predictive Ocean Atmosphere Model", which has had apparent good seasonal forecasting success in recent years. Part IV brings *Dynamics and Predictability* to a global focus, with five thoughtful chapters. In Chapter 16, Richard Grotjahn, acclaimed for his work on upper air analysis in the western United States (notably California), offers a superb assessment of models of large-scale meteorological patterns. Robin Clark of the United Kingdom's Met Office provides in Chapter 18 a succinct treatment of the increasing risk of hot days and heat warm as a result of global warming. If there is a gap in *Dynamics and Predictability*, it can be seen in this part, which would have benefited – space permitting – from a case study or modelling commentary about extreme weather in South America or perhaps Antarctica as its subject. This is undoubtedly the result of an unfortunate absence of Latin American contributors to the book.

Part V takes the reader into five chapters on the topics of ocean circulation and mesoscale effects, with case studies of the North Atlantic (the North Atlantic Oscillation), the Gulf of Guinea, Australia, along with an insightful discussion of the consequences of the Madden-Julian Oscillation by the University of Miami's Chidong Zhang. (Who notes, in conclusion, that "improvements in earth system prediction can be achieved only if we are able to better understand and predict the MJO.") These chapters could form the basis of what seems to be a needed stand-alone book on the connections between ocean circulation and extreme weather events, perhaps one with an examination of the 2014-16 El Niño (ENSO) event. *Dynamics and Predictability* is rounded out by the three chapters of Part VI, addressing the Indian summer monsoon and a predictive mechanism for it, the northwest Pacific summer climate, and extreme monsoon in the east Asian region (*i.e.* greater China). *Dynamics and Predictability* is well indexed, and each chapter features an extensive reference list. Diagrams are liberally used, and equations invariably well-explained and correct. This largely qualitative work is an evident resource for the teaching of senior-level undergraduate courses, notably in atmospheric and meteorological sciences, and also physical oceanography programs. Climate change and international environmental policy teachers will find *Dynamics and Predictability* a useful reference. And, of course, it deserves a place on the bookshelves of practicing meteorologists.

2017 will reveal humanity to be squarely in the age of climate adaptation. There are three phenomena which make accurate prediction of extreme weather events necessary, namely, the extensive interdependence of peoples on a global economy at risk from adverse weather and climate change events, migration-refugee movements and related conflicts and, not least, the increasing effects of climate change itself. The cornerstone of ensuring adaptation to extreme weather is surely both long-term synoptic understanding of relevant mechanisms, and models and forecasting that are reliable for episodic events. *Dynamics and Predictability of Large-Scale, High-Impact Weather and Climate Events* is a milestone of scientific understanding, a timely work that will serve a wide readership.



Radar Meteorology: Principles and Practice

Par Frédéric Fabry

Cambridge University Press, ISBN 978-1-107-07046-2,
2015, Hardback, 256 pages, $81.95.

Revue par Claude Lelièvre[1]

Ce livre plaira sûrement aux utilisateurs des données radar ainsi qu'aux amateurs de météorologie. Les nombreuses illustrations et graphiques mettent en valeur les propos de M. Fabry. Il s'agit d'un bon livre de référence sur la météorologie radar.

Le premier chapitre présente un résumé de l'histoire de la météorologie radar, au début de la seconde Guerre Mondiale, lorsqu'il a été réalisé qu'une partie des échos radar utilisant des magnétrons étaient causés par la précipitation. M. Fabry présente ensuite certaines des utilisations actuelles des radars et dédie une petite section sur la compréhension des observations radar.

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Le chapitre 2 aborde les principes de base des mesures météorologiques radar. Un radar comprend différentes composantes. Le transmetteur radar émet un signal micro-onde de forte intensité. L'antenne concentre le signal dans une direction. L'antenne reçoit ensuite le faible signal des hydrométéores, le concentre en direction du récepteur radar. Des processeurs de signaux extraient le maximum d'information des signaux reçus. Des équipements et logiciels spécialisés traitent alors ces données pour produire des informations pertinentes pour les utilisateurs. La seconde partie de ce chapitre traite de la propagation des ondes radars dans l'atmosphère et de leur dispersion par les hydrométéores. La dernière section mentionne trois façons habituelles de présenter les images radar : PPI (« plan position indicator »), RHI (« range-height indicator ») et HTI (« height-time indicator »).

Le chapitre 3 présente la réflectivité radar et ses dérivés. Il est particulièrement intéressant de voir comment le taux de pluie (R) est relié à la réflectivité (Z), par l'équation $Z = a R^b$. Lorsque a vaut 200 et b vaut 1.6, nous obtenons alors la fameuse relation Marshall-Palmer dérivée dans les années 1950. Ces valeurs sont généralement représentatives de la pluie tombant de pluie continue due à des systèmes synoptiques. Dans le cas d'averses tropicales, des valeurs de a de 300 et de b de 1.4 seraient plus appropriées. La présentation de données sous forme CAPPI (Constant-altitude plan position indicator) est généralement employée au Canada à une hauteur de 1.5 km. Cette présentation utilise les informations provenant des balayages radar à divers angles.

Le chapitre 4 aborde la question des patrons de réflectivité : types de cibles, processus de précipitation, structure verticale des échos de pluie, bande brillante, précipitation solide, cibles météorologiques qui ne précipitent pas et cibles non météorologiques (telles que les oiseaux et insectes).

Le chapitre 5 présente les mesures Doppler qui permettent de déterminer en partie le déplacement des échos et peuvent aider à éliminer certains échos stationnaires. M. Fabry discute des profileurs de vents.

Le chapitre 6 introduit les radars à polarisation double. Ce type de radar permet souvent d'inférer le type de précipitation, ce qui peut améliorer l'estimation des taux de pluie.

Le chapitre 7 concerne la surveillance des tempêtes convectives qui ont une durée de vie de l'ordre d'une heure. La prévision des orages est essentiellement limitée à la dernière demi-heure de leur existence.

Le chapitre 8 présente la surveillance des systèmes météo couvrant de grandes régions. M. Fabry examine un cas de prévision de tempête hivernale et discute des cyclones tropicaux.

Le chapitre 9 est la plus pertinente pour les victimes des dommages dus aux pluies d'orages : l'estimation des hauteurs de précipitation à l'aide des données radar. M. Fabry discute des diverses sources d'erreur. M. Fabry souligne le fait qu'il est difficile de développer un système opérationnel qui corrige en temps réel les erreurs d'estimation des quantités de pluie au sol à partir des données radar. Selon M. Fabry, il n'existe présentement pas de méthode optimale pour trouver les valeurs de a et de b de l'équation Z-R mentionnée précédemment. Les approches basées sur la polarisation pourraient produire de meilleurs résultats dans le futur. Les problèmes sont encore plus complexes avec la neige dont les flocons sont de formes différentes et qui peuvent tomber au sol très loin de leur emplacement de détection. M. Fabry mentionne l'importance de ne pas faire l'hypothèse de taux de précipitation constant entre les périodes successives de données radar. Il faut tenir compte du déplacement des systèmes et de l'évolution des intensités des échos radar pour obtenir une distribution plus réaliste de la précipitation au sol. La correction du biais entre les données radar et celles au sol est importante à réaliser à l'échelle d'un bassin. Il ne faut pas faire cette correction aux stations individuelles, mais à l'ensemble des données.

Le chapitre 10 discute de l'utilisation des données radar en prévision immédiate (nowcasting). Certains modèles de prévisions des échos radars existent, mais ils utilisent surtout le déplacement des échos actuels sans modifications. M. Fabry indique que peu de succès a été obtenu dans les cas d'intensification des échos radar, tandis qu'une certaine habilité a été démontrée dans les cas de leur affaiblissement.

Les chapitres 11 et 12 discutent d'applications spécialisées des radars. Le chapitre 13 discute de ce que le radar mesure en réalité. L'annexe A devrait satisfaire les amateurs des mathématiques et des statistiques en météorologie radar.

Other CMOS News

Patrick Roussel joins CMOS Council

Patrick holds a Master's degree in Engineering from École Nationale Superieure des Telecommunications, Paris, France, and a Master's degree in Physical Oceanography from Université de Bretagne Occidentale, Brest, France. Patrick worked in the fields of remote sensing and robotics before joining Amec Foster Wheeler where he has been Senior Oceanographer for the past 17 years.

Patrick takes over from Bill Merryfield as one of CMOS' three Councillors-at-large.

Books in search of a Reviewer*:

(2014-1) *Biogeochemical Dynamics at Major River-Coastal Interfaces, Linkages with Global Change,* 2014.
Edited by Thomas S. Bianchi, Mead A. Allison, Wei-Jun Cai, Cambridge University Press, 978-1-107-02257-7, Hardback, 658 pages, $146,95.

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

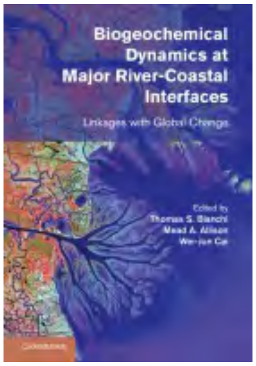
(2016-2) *Heliophysics: Active Stars, their Astrospheres, and Impacts on Planetary Environments*, 2016.
Edited by Carolus J. Schrijver, Frances Bagenal, and Jan J. Sojka, Cambridge University Press, ISBN 978-1-107-09047-7, Hardback, 406 pages, $68.95

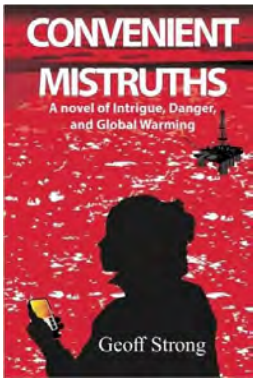
(2016-5) *Convenient Mistruths: A novel of Intrigue, Danger and Global Warming*, by Geoff Strong, 2016.
Published by Geoff Strong, ISBN 978-0-9952883-0-0, Paperback, 246 pages, $19.99

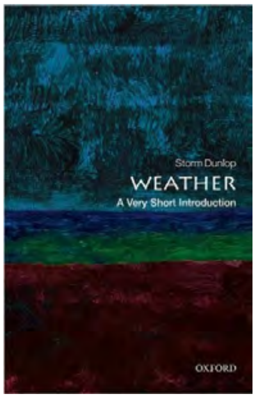
(2016-6) *Weather in the Courtroom: Memoirs from a Career in Forensic Meteorology*, by William H. Haggard, 2016.
Published by the American Meteorological Society, ISBN 978-1-940-03395-2, paperback, $30.00

(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

You review it, yours to keep!







Ocean articles, news and more in the January issue of the Canadian Ocean Sciences Newsletter *(see http://cncscor.ca/site/canadianprogram/newsletter)*, **including:**

The Development of a Numerical Water Circulation Model of Shelburne, Nova Scotia for Aquaculture Support, S.P. Haigh, D.G. Pratomo, F.H. Page, R.J. Losier, D.A. Greenberg and B.D. Chang

Other CMOS News

Publications of the Canadian Branch of the RMS

Bulletin readers will know that we are including many anniversary items at this time. The CMOS on-line Archives are undergoing continual improvement and the section containing all the publications by the Canadian Branch of the Royal Meteorological Society (RMS) has just been completed. While doing the rescanning and organizing I read several of these papers and many of them are building blocks for the improved atmospheric science which took place during our anniversary period (1967-2017). The RMS papers were written earlier (1950s) and can easily be found in the Archives.

They are fascinating, and I would like to recommend at least three to readers:

- r0601 February 1955 - **Meteorology - 2000 A.D.** - D.P. McIntyre - a 45-year forecast of what meteorology would be like in 2000.
- r0501 March 1954 - **The Weather on Television** - Percy Saltzman - a look at how TV weathercasting started and would develop in future.
- r0501 December 1954 - **Hurricanes** - R.A. Hornstein - a look at their impacts in Canada, well before the Canadian Hurricane Centre was conceived.

Bob Jones, CMOS Archivist

Atmosphere-Ocean 55-1 Paper Order

Special Issue / Numéro special

Proceedings of the Twenty-Second Quadrennial Ozone Symposium / Comptes-rendus du vingt-deuxième Symposium quadriennal sur l'ozone

Applied Research / Recherche appliquée

Upper-Level Winds over Southern Ontario: O-QNet Wind Profiler and NARR Comparisons
Peter A. Taylor, Wensong Weng, Zheng Qi Wang, Mathew Corkum, Khalid Malik, Shama Sharma, and Wayne Hocking

Along-Channel Winds in Howe Sound: Climatological Analysis and Case Studies
Talaat Bakri, Peter Jackson, and Ford Doherty

Verification of the Weather Research and Forecasting Model when Forecasting Daily Surface Conditions in Southern Alberta
Clark Pennelly and Gerhard Reuter

Fundamental Research/Recherche fondamentale

Évolution des indices des extrêmes climatiques en République du Tchad de 1960 à 2008
Abdoulaye Bedoum, Clobite Bouka Biona, Bell Jean Pierre, Issak Adoum, Robert Mbiake, and Laohoté Baohoutou

North Pacific SST Forcing on the Central United States "Warming Hole" as Simulated in CMIP5 Coupled Historical and Uncoupled AMIP Experiments
Zaitao Pan, Chunhua Shi, Sanjiv Kumar, and Zhiqiu Gao

Next Issue CMOS Bulletin SCMO

The next issue of the CMOS Bulletin SCMO will be published in April 2017. Please send your articles, notes, workshop reports or news items before March 6th, 2017, to bulletin@cmos.ca.

This publication is produced under the authority of the Canadian Meteorological and Oceanographic Society. Except where explicitly stated, opinions expressed in this publication are those of the authors and are not necessarily endorsed by the Society.

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Prochain numéro du CMOS Bulletin SCMO

Le prochain numéro du CMOS Bulletin SCMO paraîtra en avril 2017. Prière de nous faire parvenir avant le 6 mars 2017 vos articles, notes, rapports d'atelier ou nouvelles à bulletin@cmos.ca.

Cette publication est produite sous la responsabilité de la Société canadienne de météorologie et d'océanographie. À moins d'avis contraire, les opinions exprimées sont celles des auteurs et ne reflètent pas nécessairement celles de la Société.

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