



CMOS
BULLETIN
SCMO

*Canadian Meteorological
and Oceanographic Society*

*La Société canadienne de
météorologie et d'océanographie*

August / août 2020

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2020 Arctic Summer Seasonal Climate Outlook for Sea-Ice by Gascon et al.



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A Note on ECCC Radar Snowfall Estimates and Radar Data by Hassan et al.



Micrometeorological Variables and Atmospheric Dispersion Modeling in Two Climate Regions of Quebec by Richard Leduc & Jean-François Brière



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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.

Words from the Presidents

Kimberly Strong Hands Over CMOS Presidency to Marek Stastna

Dear CMOS Friends and Colleagues,

June marks the end of my year as CMOS President. It has been an honour to serve in this role, which has been both eventful and rewarding, particularly over the last several months. I sincerely thank CMOS staff, Council, Executive, Centre Chairs, and Committee Chairs and members, for their support and for all their contributions to CMOS over the past year.

Last summer, I described three areas that I wanted to focus on in 2019-20 and I'd like to briefly report on some accomplishments.

Membership and Student Involvement: I'm pleased that we now have a Membership Code of Conduct, which sets out the principles (respect, responsibility, fairness, honesty, and integrity) and responsibilities of members' engagement with CMOS. We undertook a year-long consultation process, with an initial draft presented at the 2019 AGM, revisions based on feedback from members and a legal opinion, resulting in approval at the 2020 AGM. On the student front, our Student Committee was active this year, under the very capable leadership of its Chair, Ellen Gute. They posted a series of tweets on CMOS student research last winter, visited university classes to talk about CMOS, and sent a survey to all 244 student members. This found that student networking, professional development, and educational outreach are equally important reasons for joining CMOS, that student members would like to see more job postings, career pathways, internship opportunities, and scholarships, as well as a remote career session. Rather sobering was the discovery that <1% of respondents were aware of activities in their local CMOS Centre, so we certainly have some work to do there.



Outreach and Visibility: CMOS released a Position Statement on Climate Change last summer and endorsed the AMOS Position Statement on International Cooperation and Data Sharing. We have created a CMOS slide deck, postcard, information leaflet, and stickers, all of which are available to members (via exec-dir@cmos.ca). We made our Facebook page publicly accessible and set up a Website Working Group, which has been providing guidance to our website provider Olatech on the development of a new and modernized CMOS website, which we hope to roll out soon. Plans are also underway to improve coordination between our various communications platforms and further increase CMOS visibility.

Education and Mentorship: This year has seen the reinvigoration of our School and Public Education Committee, with the recruitment of new members, a much-needed revision of its Terms of Reference, which articulates its focus on developing an educational role for the Society for youth and for the public at large. We assisted ECCC with their recruitment efforts, posting and circulating their pamphlets on Meteorological Careers and Recruitment Opportunities.

A major event this spring was moving the 54th CMOS Congress online as a result of the COVID-19 pandemic. This had been scheduled for May 24-28 in Ottawa, but was converted to an extended virtual event that ran from May 26 to June 15. About 180 presentations were given across 16 sessions and more than 900 registrants attended. Our annual Awards Ceremony also went virtual, with an online celebration of recipients held on June 11. We received a lot of positive feedback through our participant survey as well as helpful suggestions for future Congresses. Congratulations to the ad hoc organizing committee, the session conveners, presenters, and attendees for making the Virtual Congress a great success on a very tight timeline. I'd also like to thank the Ottawa LAC and SPC for all the work they did for the 54th Congress.

This spring has also seen an outpouring of grief, anger, and calls for action in response to multiple incidents of violence against Black and Indigenous people in Canada and the USA. On June 5, we released the CMOS Statement on Racism: A Time to Act, adding our voice to those of our fellow scientific societies to affirm our support for equity, inclusion, and diversity. Although this resulted in one cancelled membership, others responded positively, e.g., "Bravo! Thank you for this heartfelt, eloquent statement." and "Thanks for doing this. Makes me proud of my Society." A few days later, we responded to the call for professional societies to participate in a world-wide academic and STEM strike in support of Black Lives, rescheduling the CMOS Virtual Congress session planned for June 10. There is much that needs to be done to address issues of racism, and I hope that CMOS will build on these initial steps and take action to ensure an equitable culture within our Society.

Words from the Presidents

There is much good work for CMOS to do, and I know that it will be in excellent hands with our incoming President, Marek Stastna. Marek is a Professor of Applied Mathematics at the University of Waterloo and has served as CMOS Vice-President for the last year. With his scientific expertise in geophysical fluid dynamics, his concern for students, his administrative experience, his belief in the importance of volunteer service, and his dedication to CMOS, Marek is ideally qualified to lead our Society. I have greatly enjoyed working with him and look forward to continuing to do so over the coming year. Over to you Marek!

Kimberly Strong

CMOS Past-President, and Professor & Chair, Department of Physics, University of Toronto
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Dear Colleagues,

I am honoured to serve as your CMOS President for the 2020-2021 term. As I sit down to attempt to make sense of the last four tumultuous months, the Southern Ontario summer has settled into its usual sun baked pattern. Each day begins with the dawn songs of the birds in my backyard, and then rapidly heats to sit outside of the human comfort zone. On most days the heat is accompanied by relentless humidity, and it really isn't until the Sun reaches a particularly acute angle in the evening that the outside world truly welcomes people again. As someone who grew up at the very southern extremity of Canada, the local climates of our giant country have always amazed me, and over the past year this has been sharpened by the diversity of perspectives I have heard at the CMOS Centre Chairs meetings, and of course through the subsequent physical isolation of the quarantine.



Professionally, days are filled with electronic meetings, and it really is some sort of wonder how quickly the life of “too many physical meetings” shifted to a life of “too many electronic meetings”. Though, for a few glorious weeks there, my inbox was remarkably free of unanswered emails and all my reviews were in on time! For some of my students, the quarantine has not changed much, and the ability to focus on their research has led to a flowering of activity. For others though, the casual social interaction, and the soft pressure an academic environment provides are both sorely missed. Moreover, many employer organizations have painted the shift to working from home as something that is far easier than the puzzle our complex, modern life poses.

CMOS as an organization has weathered the storm reasonably well. We have hosted a Virtual Congress that, despite a very short run in, had a turnout that was competitive with our largest Congresses (and the organizers associated with the Virtual Congress, mainly in the Ottawa Centre, should take a well deserved, bow). We have also had our first fully electronic AGM, which while revealing demographic pressure points in our society, certainly proved active. Thus both the true business (i.e. science) and the technical business of the society have seemingly made the adjustment to the electronic format. Over the coming months we will assess the extent to which the financial side of CMOS weathered the storm, and we will begin in earnest, both the 2020-2021 year of activities that will culminate in the 55th Victoria-led Congress and a larger exercise of revising the CMOS Strategic Plan.

The question of whether the present state of the world is a speed bump or a fork in the road is not easy to answer. Some of the answers will be personal; I know, for example, that I will never travel as much as I did in the two years prior to the pandemic. Other aspects may well be beyond our individual control. It is certainly unclear what the long term funding prospects look like for basic science in an economic reality that will bear the marks of the necessary COVID-19 related expenditures for a decade or more. Moreover, the negative effects of a changing climate are disproportionately borne by those with the least resources to make necessary adjustments, and as we face funding pressures on science, this more basic fact should not be forgotten.

Words from the Presidents

I thus believe it is imperative that the voice of CMOS, be it in Zoom/Webex meetings, through our publications, or on social media, is loud in its advocacy for both our science and our scientists in the broadest sense possible. Indeed if there is any clear message from the Virtual Congress, it is that the electronic mode of delivery allows for a long overdue democratization of science. I would challenge all of us to build on these small, first steps in the coming year in an effort at modernizing our Society and preparing it for the challenges of the future. In particular, while the profound changes in the climate system are ongoing, it is clear that media and political awareness of climate issues has taken a back seat to more immediate, COVID-19 related concerns.

It is customary at this point to thank the outgoing and welcome the incoming volunteers. Like all scientific societies, CMOS is only as strong and active as those who volunteer their time for it. I wish nothing but the best for the outgoing volunteers:

- Recording Secretary Fred Conway
- Past-President Paul Kushner
- Councillor-at-Large Bob Sica
- Councillor-at-Large Douw Steyn (who is continuing in the role of Publications Director and Privacy Officer)
- Student Committee Chair Ellen Gute.

At the same time, I look forward to working with the incoming cohort:

- Vice President Jim Abraham
- Recording Secretary Alexandre Audette
- Councillor-at-Large Dominique Paquin
- Student Committee Chair and Councillor-at-Large Chris Poitras.

I also want to acknowledge all the ongoing volunteers in their various roles.

On a final note, I am by nature, a talker. As imperfect as it is, email can be a great start to a conversation, and I look forward to hearing from any CMOS member, or prospective member, on any issue they would like to bring to my attention. A close second to sending me an email, would be to contribute an interesting article to our ever-changing, and very sharp looking Bulletin!

Marek Stastna

CMOS President, and Professor, Department of Applied Mathematics, University of Waterloo
Email: president@cmos.ca

Mots des présidents

Kimberly Strong remet la présidence du SCMO à Marek Stastna

Chers amis et collègues de la SCMO,

Le mois de juin marque la fin de mon année comme présidente de la SCMO. Ce fut un honneur pour moi d'assumer ce rôle, qui a été à la fois fécond en événements et enrichissant, notamment au cours des derniers mois. Je tiens à remercier sincèrement le personnel de la SCMO, le conseil d'administration, les cadres, les présidents des centres et des comités de même que les membres, pour leur soutien et l'ensemble de leur contribution à la SCMO durant l'année qui vient de s'écouler.

L'été dernier, j'ai décrit trois secteurs d'intervention privilégiés en 2019-2020, et j'aimerais brièvement souligner quelques-unes de nos réalisations.



Adhésion et participation des étudiants. Je suis ravie que nous disposions désormais d'un [Code de conduite pour les membres](#), lequel énonce les principes (respect, responsabilité, équité, honnêteté et intégrité) ainsi que les responsabilités en matière d'engagement des membres auprès de la SCMO. Nous avons entrepris un processus de consultation qui s'est étalé sur l'année, et dont l'ébauche initiale a été présentée lors de l'AGA de 2019. Des révisions ont été apportées à la suite de la rétroaction des membres et d'un avis juridique, menant à son approbation lors de l'AGA de 2020. Du côté des étudiants, notre Comité des étudiants n'est pas resté en reste cette année sous la bonne direction d'Ellen Gute, sa présidente. Ses membres ont publié une série de gazouillis sur les recherches effectuées par des étudiants de la SCMO l'hiver dernier, se sont rendus dans des classes à l'université pour parler de la SCMO et ont fait parvenir un sondage aux 244 membres étudiants. Les constatations ont révélé que le réseautage entre étudiants, le perfectionnement professionnel et le faire-savoir en matière d'éducation sont des raisons tout aussi importantes d'adhérer à la SCMO, que les membres étudiants aimeraient obtenir davantage d'avis de postes vacants, de cheminement de carrière, d'occasions de stage et de bourses d'études, ainsi qu'une séance à distance sur les carrières. Il faut se désoler du fait que moins de 1 % des répondants étaient au courant des activités du centre de la SCMO de leur localité, alors nous avons assurément du travail à faire à ce niveau.

Rayonnement et visibilité. L'été dernier, la SCMO a publié un [Énoncé de position sur les changements climatiques](#) et a approuvé l'[Énoncé de position sur la coopération internationale et le partage de données de l'AMOS](#). Nous avons créé un jeu de diapositives, une carte postale, une brochure et des autocollants de la SCMO, lesquels sont mis à la disposition des membres (via exec-dir@cmos.ca). Notre page Facebook est accessible au public et nous avons créé un groupe de travail sur le site Web qui a fourni des conseils à Olatech, le fournisseur de notre site Web, concernant le développement d'un nouveau site Web modernisé de la SCMO que nous espérons lancer sous peu. Des préparatifs sont aussi en cours pour améliorer la coordination entre nos différentes plateformes de communication et renforcer ainsi la visibilité de la SCMO.

Éducation et mentorat. Cette année, notre Comité d'éducation scolaire et publique a connu un nouvel élan grâce au recrutement de nouveaux membres, à une révision nécessaire de son [mandat](#), lequel énonce son objectif de créer une visée éducative pour la Société visant les jeunes et le public en général. Nous avons contribué aux initiatives de recrutement d'ECCC, à leur affichage de postes ainsi qu'à la distribution de leurs brochures sur les [carrières en météorologie](#) et les [possibilités de recrutement](#).

Un événement majeur survenu au cours du printemps a été la tenue du [54e Congrès de la SCMO](#) en ligne en raison de la pandémie de COVID-19. Cet événement devait avoir lieu du 24 au 28 mai à Ottawa, mais s'est transformé en événement virtuel prolongé, soit du 26 mai au 15 juin. Environ 180 présentations ont été données au cours de 16 séances, et plus de 900 personnes inscrites y ont participé. Notre cérémonie de remise des prix annuelle s'est aussi déroulée de façon virtuelle avec la tenue d'une [célébration des lauréats](#) en ligne le 11 juin. Nous avons reçu énormément de rétroaction positive par l'entremise de notre sondage auprès des participants ainsi que des suggestions utiles pour les prochains congrès. Je tiens à féliciter le comité d'organisation spécial, les animateurs des séances, les présentateurs et les participants qui ont assuré le franc succès du Congrès virtuel, et ce, dans un délai très serré. J'aimerais aussi remercier le Comité des dispositions locales (CDL) et le Comité du programme scientifique (CPS) d'Ottawa pour tout leur travail en vue de la tenue du 54e Congrès.

Au cours du printemps, nous avons également été témoins d'un déferlement de tristesse, de colère et d'appels à l'action en réponse aux nombreux incidents de violence contre des personnes noires et autochtones au Canada et aux États-Unis. Le 5 juin, nous avons publié l'[Énoncé de la SCMO sur le racisme](#) : il est temps d'agir, ajoutant notre voix à celle d'autres sociétés scientifiques afin d'affirmer notre soutien aux valeurs d'équité, d'inclusion et de diversité. Bien que cette mesure ait entraîné l'annulation d'une adhésion, d'autres ont réagi de façon positive, notamment en nous

Mots des présidents

envoyant des messages comme « Bravo! Merci de cet énoncé éloquent venant du fond du cœur » et « Merci de prendre position. Cela me rend fier de ma Société ». Quelques jours plus tard, nous avons répondu à l'appel de sociétés professionnelles visant à participer à une grève du milieu universitaire et des STIM à l'échelle mondiale à l'appui du mouvement Black Lives, [reportant à une date ultérieure la séance du Congrès virtuel de la SCMO](#) qui était prévue pour le 10 juin. Il reste beaucoup à faire pour s'attaquer aux problèmes de racisme, et j'espère que la SCMO s'inspirera de ces premières étapes et agira afin d'assurer une culture équitable au sein de notre Société.

La SCMO peut encore accomplir beaucoup de bon travail et je sais que nous serons en de très bonnes mains avec Marek Stastna, notre nouveau président. Marek enseigne les mathématiques appliquées à l'Université de Waterloo et a agi en qualité de vice-président de la SCMO au cours de la dernière année. Fort de son expertise scientifique en dynamique des fluides géophysiques, de sa sollicitude à l'égard des étudiants, de son expérience administrative, de sa croyance en l'importance du service bénévole et de son dévouement envers la SCMO, Marek a toutes les compétences qu'il faut pour diriger notre Société. J'ai adoré travailler avec lui et je suis impatiente de continuer à le faire au cours de l'année à venir. Je te passe le flambeau Marek!

Kimberly Strong

Ancienne présidente de la SCMO et professeure et présidente, Département de physique, Université de Toronto
Courriel : past-president@cmos.ca

Chers collègues,

Je suis honoré d'agir à titre de président de la SCMO pour la période 2020-2021. Alors que je prends un temps d'arrêt pour tenter de donner un sens aux quatre derniers mois fort mouvementés, l'été s'est installé dans le sud de l'Ontario sous un habituel soleil de plomb. Ma journée commence à l'aube avec le chant des oiseaux dans ma cour arrière, où il fait rapidement trop chaud pour s'y asseoir confortablement. La majorité du temps, la chaleur s'accompagne d'une humidité permanente, et ce n'est vraiment qu'en soirée, lorsque le Soleil atteint un angle particulièrement aigu, que le monde extérieur est encore une fois prêt à accueillir le genre humain. Ayant grandi dans l'extrême sud du Canada, les climats locaux de notre gigantesque pays m'ont toujours stupéfié. Au cours de la dernière année, cette impression a été exacerbée par la diversité des points de vue que j'ai entendus au cours des réunions du Comité des présidents des centres de la SCMO et, bien entendu, lors de l'isolement physique ultérieur découlant de la mise en quarantaine.



Sur le plan professionnel, mes journées sont remplies de réunions en ligne, et c'est vraiment prodigieux la rapidité à laquelle la vie composée de « trop de réunions en personne » s'est transformée en « trop de réunions en ligne ». Par contre, pendant quelques glorieuses semaines, ma boîte aux lettres était remarquablement exempte de courriels non répondus et toutes mes évaluations étaient remises à temps! Pour certains de mes étudiants, la mise en quarantaine n'a pas changé grand-chose, et la capacité de se concentrer sur leurs travaux de recherche a conduit à un bourdonnement d'activité. En revanche, d'autres ont beaucoup souffert de l'absence d'interactions sociales et de la pression rassurante du milieu universitaire. Qui plus est, beaucoup d'organisations-employeurs ont décrit le passage du travail à domicile comme étant beaucoup plus facile que le casse-tête posé par notre style de vie moderne complexe.

Comme organisation, la SCMO a assez bien affronté la tempête. Nous avons organisé un Congrès virtuel qui, malgré un rodage très rapide, a obtenu un taux de participation comparable à celui de nos plus grands Congrès (et le travail des organisateurs du Congrès virtuel, principalement dans le secteur Ottawa-Centre, mérite d'être salué). Nous avons aussi tenu notre toute première AGA entièrement en ligne, laquelle, bien qu'ayant mis au jour des sources de tension démographique dans notre société, s'est certainement avérée active. Par conséquent, le véritable secteur d'activité (c.-à-d. la science) et l'aspect technique de la société, se sont vraisemblablement adaptés au format électronique. Au cours des prochains mois, nous évaluerons la mesure dans laquelle le volet financier de la SCMO a affronté la tempête, et nous entreprendrons sérieusement l'année d'activités 2020-2021 qui aboutira au 55e Congrès à Victoria ainsi qu'un exercice plus vaste de révision du Plan stratégique de la SCMO.

Mots des présidents

des organisateurs du Congrès virtuel, principalement dans le secteur Ottawa-Centre, mérite d'être salué). Nous avons aussi tenu notre toute première AGA entièrement en ligne, laquelle, bien qu'ayant mis au jour des sources de tension démographique dans notre société, s'est certainement avérée active. Par conséquent, le véritable secteur d'activité (c.-à-d. la science) et l'aspect technique de la société, se sont vraisemblablement adaptés au format électronique. Au cours des prochains mois, nous évaluerons la mesure dans laquelle le volet financier de la SCMO a affronté la tempête, et nous entreprendrons sérieusement l'année d'activités 2020-2021 qui aboutira au 55e Congrès à Victoria ainsi qu'un exercice plus vaste de révision du Plan stratégique de la SCMO.

Il n'est pas facile de répondre à la question visant à déterminer si l'état actuel du monde est un ralentisseur ou une croisée des chemins. Certaines des réponses seront d'ordre personnel; par exemple, je sais que je ne voyagerai jamais autant que je le faisais dans les deux années précédant la pandémie. D'autres aspects pourraient fort bien être indépendants de notre volonté individuelle. Il ne fait aucun doute que nous ignorons la forme que prendront les perspectives de financement à long terme pour la science fondamentale dans un contexte économique qui portera les marques des dépenses connexes nécessaires liées à la COVID-19 pendant au moins une décennie. De surcroît, les effets négatifs des changements climatiques sont subis de façon disproportionnée par ceux qui ne disposent pas des ressources nécessaires pour apporter les changements nécessaires. Alors que nous sommes confrontés aux pressions de financement exercées sur la science, ce fait fondamental ne doit pas être oublié.

Par conséquent, je suis d'avis qu'il est indispensable que la voix de la SCMO, qu'il s'agisse de réunions Zoom/Webex, dans nos publications ou sur les médias sociaux, clame haut et fort son importance à la fois pour notre science et pour nos scientifiques au sens le plus large possible. En effet, s'il y a un message clair à retenir du Congrès virtuel, c'est que le mode électronique de communiquer permet une démocratisation de la science attendue depuis longtemps. Je nous mettrai tous au défi de s'inspirer de ces modestes premiers pas au cours de l'année à venir pour moderniser notre Société et la préparer à relever les défis de l'avenir. Il est notamment apparent que, bien que les changements profonds survenus dans le système climatique soient continus, la sensibilisation des médias et de la sphère politique aux enjeux climatiques a été reléguée à l'arrière-plan au profit de préoccupations plus immédiates liées à la COVID-19.

Je tiens ici à remercier les bénévoles qui nous quittent et à accueillir les nouveaux bénévoles. À l'instar de toutes les sociétés scientifiques, la SCMO doit sa force et son dynamisme à ceux qui y consacrent leur temps. Je souhaite le meilleur aux bénévoles qui nous quittent :

- Fred Conway, secrétaire rapporteur
- Paul Kushner, ancien président
- Bob Sica, conseiller général
- Douw Steyn, conseiller général (qui poursuit son rôle de directeur des publications et de responsable de la protection de la vie privée)
- Ellen Gute, présidente du Comité des étudiants

Parallèlement, je suis impatient de travailler avec la nouvelle cohorte :

- Jim Abraham, vice-président
- Alexandre Audette, secrétaire rapporteur
- Dominique Paquin, conseiller général
- Chris Poitras, président du Comité des étudiants et conseiller général
-

Je tiens aussi à remercier tous les bénévoles actuels qui exercent différents rôles.

Pour conclure, je vous dirais que je suis, de nature, une personne qui aime beaucoup parler. Aussi imparfait soit-il, le courriel peut être une excellente façon d'amorcer une conversation, et j'ai hâte de recevoir des nouvelles de tout membre actuel ou futur de la SCMO concernant toute question qu'ils aimeraient porter à mon attention. Tout de suite après l'envoi d'un [courriel](#) vient la contribution à un article d'intérêt à notre bulletin très agréable à regarder en perpétuelle évolution!

Marek Stastna

Président de la SCMO et professeur, Département de mathématiques pures et appliquées, Université de Waterloo
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Article: Ontario's Coldest Temperature Re-Visited

Ontario's Coldest Temperature Revisited: Setting the Record Straight

by Bryan Smith

How accurate are Canada's weather records? The case of Ontario's all-time record low temperature casts some doubt.

Canadians have free access to one of the most extensive climate databases in the world with data going back to 1840. However, despite efforts to quality-assure this data, suspicious values emerge from time to time among the millions of archived observations. The reasons for the occurrence of inaccurate data are numerous,

including: instrument error, observer error, transcription error or non-standard observing procedural error. This is a look at what I believe to be one of these errors – one that has not only existed in the archive for 85 years, but also currently stands as Ontario's all-time coldest minimum temperature.

The date was January 23, 1935. The location: Iroquois Falls, located 55 km northeast of Timmins and 40 km south of Cochrane, ON.

The value was a minus 58.1°C (minus 73°F) minimum daily temperature. The observer was a trained volunteer at the Abitibi Paper Power Plant – a co-operative climate station where daily weather observations had been taken since 1913. This minimum temperature allegedly broke the former record low of minus 57.6°C set in Hornepayne in February 1918.

However, based on spatial comparisons, it very likely that this Iroquois Falls mark is in error. As well, the original February 1918 Hornepayne record low was later shown to be in error itself and was removed from the archive.



Figure 1. Iroquois Falls is located 55 km northeast of Timmins and 40 km south of Cochrane, ON. Source: Google Maps.

Daily Minimums for January 1935 in Northeastern Ontario: A Spatial Comparison

The graph below (Fig. 3) shows the low temperatures each morning for the climate stations in Northeastern Ontario. Note that Iroquois Falls was only the coldest low on January 23. Every morning except January 23 was colder at other locations in northeastern Ontario. The January 23 minimum temperature in Iroquois Falls was very much an anomaly with a reading approximately 20 degrees Celsius colder than Timmins.

Using an average difference calculation on the minima for January 1935 comparing Iroquois Falls, Timmins and Cochrane, the following statistics were found:

While Iroquois Falls is on average colder than either Timmins or Cochrane, when the average difference is applied to the Iroquois Falls minimum for January 23; the adjusted Iroquois Falls temperature fits much better into the pattern for that morning. For example the average difference minimum temperature for the month of January 1935 was:

1. Iroquois Falls 7.4°C degrees colder than Timmins
2. Iroquois Falls 3.7°C degrees colder than Cochrane

Article: Ontario's Coldest Temperature Revisited

Applying these average differences to the Iroquois Falls morning low on January 23, it is much more likely that the minimum Iroquois Falls temperature should have been closer to minus 46 degrees C rather than minus 58 degrees C.



Figure 2. The 1935 Toronto Star clipping reporting on the record.

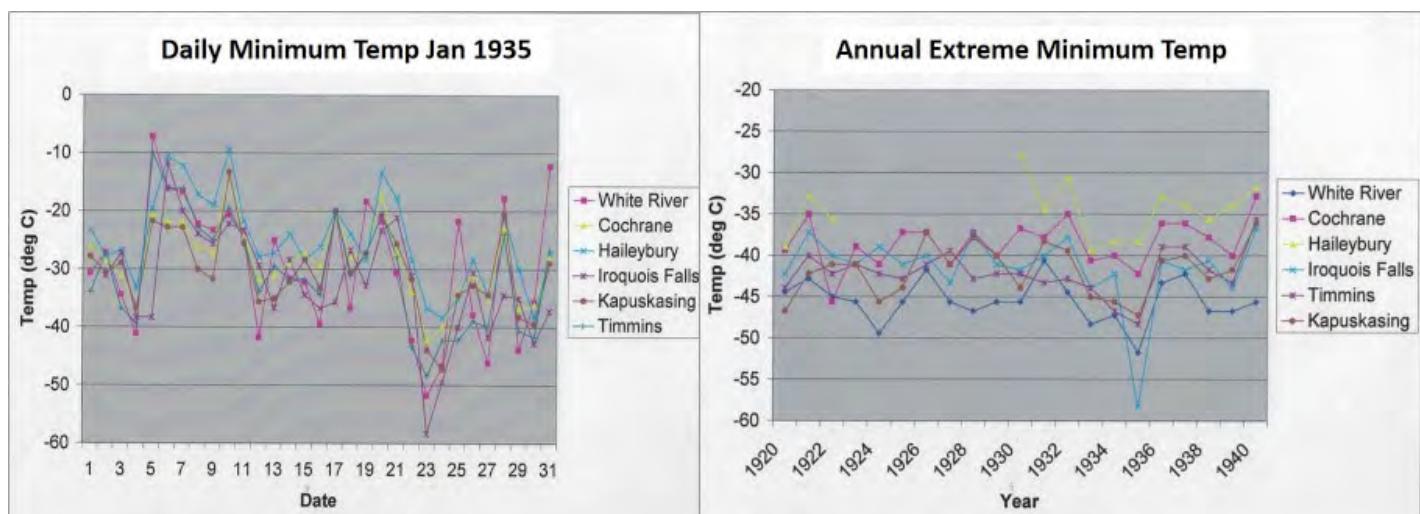
C. recorded at Lundbreck Alberta but this too was shown by spatial comparison to likely be 10°F degrees too high.

Annual Minimum Temperatures in North Eastern Ontario 1920-1940

The second graph (Fig. 4) shows annual extreme minimum temperatures in northeastern Ontario from 1920 to 1940. Again Iroquois Falls is the coldest extreme minimum only in 1935, a value that is certainly an anomaly during this 20 year period. Only once in the entire history of weather observing (1913-1998) at Iroquois Falls did a temperature less than minus 50°C occur and that was on the date of the alleged record low.

Note that the White River climate station was most often the coldest locale by year. White River however experiences cold air drainage as it sits in a broad river valley with 100 metre hills all around. The siting of the Iroquois Falls climate site was not unusual. It was sited north of the large Abitibi paper mill near a parking lot with sloping ground to the river 300 metres away.

Correcting record temperatures has been a fairly common occurrence for provinces, nations, and US states. J.G.Potter (1966, p. 36) in his paper "[The Highest Temperature in Canada ?](#)" published in 1966 stated that "it is impossible to thoroughly check the accuracy of any reported extreme values in the early records". For example in Ontario the record maximum temperature was at one time considered to be a 42.8°C maximum at Stonecliffe northwest of Pembroke. This value was subsequently found to be in error and corrected to 37.8°C. Similar decisions were made regarding Canada's highest temperature once considered to be 46.1°C set at Gleichen, Alberta in July 1903. The replacement record high was thought to be 45.6°



(Left) Figure 3. Graph of daily minimum temperatures for towns in the Northeastern region of Ontario, January 1935.
(Right) Figure 4. Annual extreme minimum temperatures for towns in the Northeastern region of Ontario.

In the USA their oldest state record was Colorado's maximum value at Bennett, set in 1888. [A review](#) by T.W. Bettge published in Weatherwise 1985 found this to be an erroneous reading.

Article: Ontario's Coldest Temperature Revisited

Extreme weather records are a fascination for people interested in the hottest, coldest, driest and wettest areas in a province or nation. Towns often leverage these facts to draw attention. Anyone who has driven the scenic highway between Sault Ste. Marie and Thunder Bay has seen the famous White River record temperature sign. Granted White River is a very cold winter spot as shown in Figure 4, but the claim as Canada's coldest town at minus 73°F (minus 58°C) is not true. Snag in the Yukon owns this record with a minus 63°C value. However this long-standing giant thermometer illustrates the interest people have in such all-time records.

Accordingly if the Iroquois Falls record low is discounted, what is the coldest recorded temperature in Ontario? There are several contenders as listed in G.R. Kendall's paper "The Coldest Place in Ontario" published in 1964.

The list includes:

- Central Patricia (located 450 km north of Thunder Bay and 5 km northeast of Pickle Lake) -53.9°C January 5, 1959.
- Hornepayne -52.8°C Jan 23, 1935
- White River -51.7°C Jan 23, 1935.
- Ingolf -51.2°C Feb 7, 1933.
- Franz -50.6°C Jan 23, 1935.
- Armstrong -50.0°C Jan 29, 1957.

Note that the January 23, 1935 date (same as the Iroquois Falls reading) is the coldest day at several stations and for this reason that date may well be the coldest day in Ontario. Although Central Patricia looks like an obvious choice, the low temperature at nearby Pickle Lake on January 5, 1959 was only minus 46.7°C (allowing for the time difference in observing programs). This temperature difference of 7.2°C degrees over such a short distance looks excessive and casts some doubt on the Central Patricia reading.



Figure 5. Giant thermometer marking White River as "The Coldest Spot".

The question remains as to Ontario's coldest ever recorded temperature. Perhaps it is best left to Environment and Climate Change Canada to use their knowledge and computing power to review all the coldest candidates to set the record straight. Records are made to be broken, but sometimes broken records need to be fixed.

Finally as alluded to earlier, this paper is a reminder that all data, even Canada's, needs to be used with some degree of caution.

References

1. Bettge, T. W. (1985). Weather records: The case of the Bennett, Colorado maximum temperature. *Weatherwise*, 38:2, 95-97. doi:10.1080/00431672.1985.9933292
2. Kendall, R.G. (1964). The Coldest Place in Ontario, CDS #3-64 published July 31 1964 Dept. of Transport Meteorological Branch Climatology Division
3. Potter, J.G. (1966) The highest temperature in Canada ?, *Atmosphere*, 4:3,29-37, DOI: 10.1080/00046973.1966.9676527



About the Author

Bryan Smith graduated from York University and Waterloo back in the last Century. He was Superintendent of the Ontario Climate Centre from 1986 until his retirement in 2005. Following retirement he founded Forensic Weather Services; a consultation service for the legal and law enforcement sectors. Bryan was a volunteer climate observer from 1981 to 2009 (Sandhill-Caledon). Publications include "The Climate of Toronto" (with Auld, Loiselle, Allsopp), "Climatology Goes to Court" and "The Changing Climate of Orangeville". Bryan and his wife divide their time between a home in Orangeville and a log cabin on the Muskoka River.

Article: Summer Arctic Temperature and Precipitation Outlook

2020 Arctic Summer Seasonal Climate Outlook for Temperature and Precipitation

By contributors from Environment and Climate Change Canada, the Arctic and Antarctic Research Institute, the Hydrometeorological Centre of Russia, The Norwegian Meteorological Institute, Finnish Meteorological Institute, World Meteorological Organization, Climate Prediction Center, and National Oceanic

Arctic Climate Forum Consensus Statement

And Summary of the 2020 Arctic Winter Season

CONTEXT

Arctic temperatures continue to warm at more than twice the global mean. Annual surface air temperatures over the last 4 years (2016–2019) in the Arctic (60° – 85° N) have been the highest in the time series of observations for 1936–2019. The extent of winter sea-ice is at record low levels, and the volume of Arctic sea-ice present in the month of September 2019 has declined by more than 50% compared to the mean value for 1979–2019. To support Arctic decision makers in this changing climate, the recently established Arctic Climate Forum (ACF) convened by the Arctic Regional Climate Centre Network (ArcRCC-Network) under the auspices of the World Meteorological Organization (WMO) provides consensus climate outlook statements in May prior to summer thawing and sea-ice break-up, and in October before the winter freezing and the return of sea-ice. The role of the ArcRCC-Network is to foster collaborative regional climate services amongst Arctic meteorological and ice services to synthesize observations, historical trends, forecast models and fill gaps with regional expertise to produce consensus climate statements. These statements include a review of the major climate features of the previous season, and outlooks for the upcoming season for temperature, precipitation and sea-ice. The elements of the consensus statements are presented and discussed at the Arctic Climate Forum (ACF) sessions with both providers and users of climate information in the Arctic twice a year in May and October, the later typically held online. This consensus statement is an outcome of the 5th session of the ACF held online on 27–28 May 2020 and coordinated by the Eurasian Node of ArcRCC-Network hosted by the Russian Federation.

HIGHLIGHTS

Warmer than normal surface air temperatures over Eurasia and the Arctic Ocean contributed to below to near normal ice conditions during the 2019–2020 winter across the entire Arctic. Forecast variability in above normal temperatures and wetter-than-average conditions across the different Arctic regions for June–August 2020 are contributing to the spatial variability in spring break-up and minimum sea ice extent forecast for the summer of 2020.

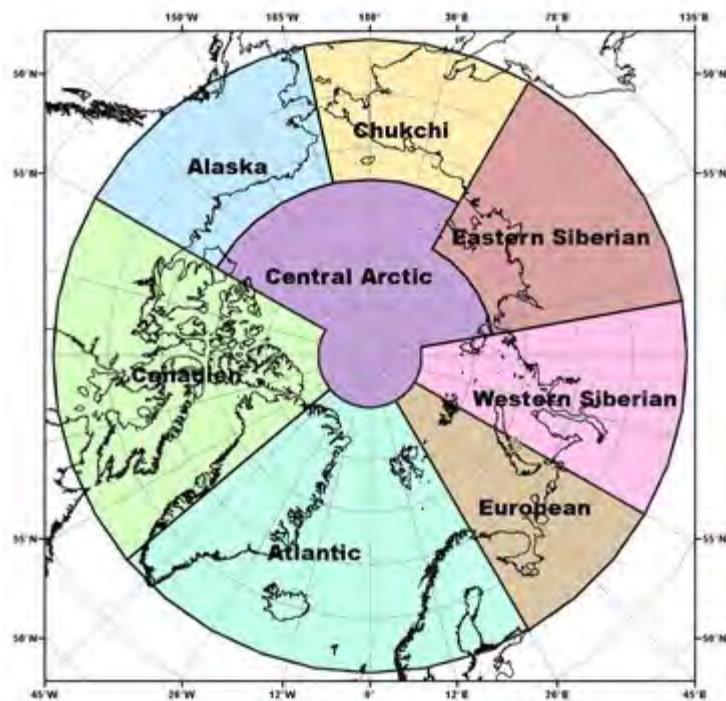


Figure 1. Regions used for the seasonal summary and outlook of temperature and precipitation.

Temperature: The average surface air temperatures for FMA 2020 ranged from lower than normal in the western hemisphere to higher than normal in the eastern hemisphere, with Siberia experiencing one of its warmest FMA on record. Above normal temperatures are expected to continue across the majority of the Arctic for June–August 2020.

Precipitation: Wetter than average conditions during FMA 2020 were observed across the majority of the Arctic. Wetter than normal conditions are expected to continue across Alaska, and portions of the Chukchi, Eastern Siberia, and northern Canadian regions.

UNDERSTANDING THE CONSENSUS STATEMENT

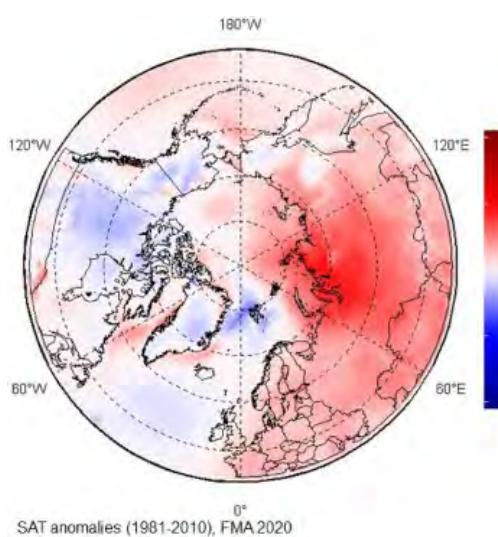
This consensus statement includes: a seasonal summary and forecast verification for temperature and precipitation for previous 2020 Arctic winter season (February, March, and April 2020); an outlook for the upcoming 2020 Arctic summer season (June, July, and August 2020). Figure 1 shows the regions that capture the different geographic features and environmental factors influencing temperature/precipitation.

Article: 2020 Temperature & Precipitation Arctic Outlook

The temperature and precipitation forecasts are based on eight WMO Global Producing Centers of Long-Range Forecasts (GPCs-LRF) models and consolidated by the WMO Lead Centre for Long Range Forecast Multi-Model Ensemble (LC-LRFMME). In terms of models' skill (i.e. the ability of the climate model to simulate the observed seasonal climate), a multi-model ensemble (MME) approach essentially overlays all of the individual model performances. This provides a forecast with higher confidence in the regions where different model outputs/results are consistent, versus a low confidence forecast in the regions where the models don't agree. The MME approach is a methodology well-recognized to be providing the most reliable objective forecasts.

TEMPERATURE

Summary for February, March, and April 2020:



The February, March, and April (FMA) 2020 average surface air temperatures in the Arctic north of 65°N ranged from higher than normal in the eastern hemisphere, to lower than normal in the western hemisphere (Figure 2). Due to very low atmospheric pressure on the Eastern side of the Arctic (ERA5, not shown here), Scandinavia and the majority of the Eastern and Western Siberia regions experienced warmer than normal conditions (red areas in Figure 2), while the majority of Canada, Alaska, Greenland, and the North Atlantic Ocean experienced near normal (white areas in Figure 2) or slightly below normal (light blue areas in Figure 2) conditions. Using data from NCEP/NCAR reanalysis to rank the average surface air temperature, the boundary between Eastern and Western Siberia saw their second warmest FMA period, on average, since the start of the record in 1949 (not shown).

Figure 2. February, March, and April (FMA) 2020 surface air temperature anomaly based on the 1981-2010 reference period. Red indicates warmer than normal temperatures, and blue indicates cooler than normal temperatures. Map produced by the Arctic and Antarctic Research Institute <http://www.aari.ru>. Data

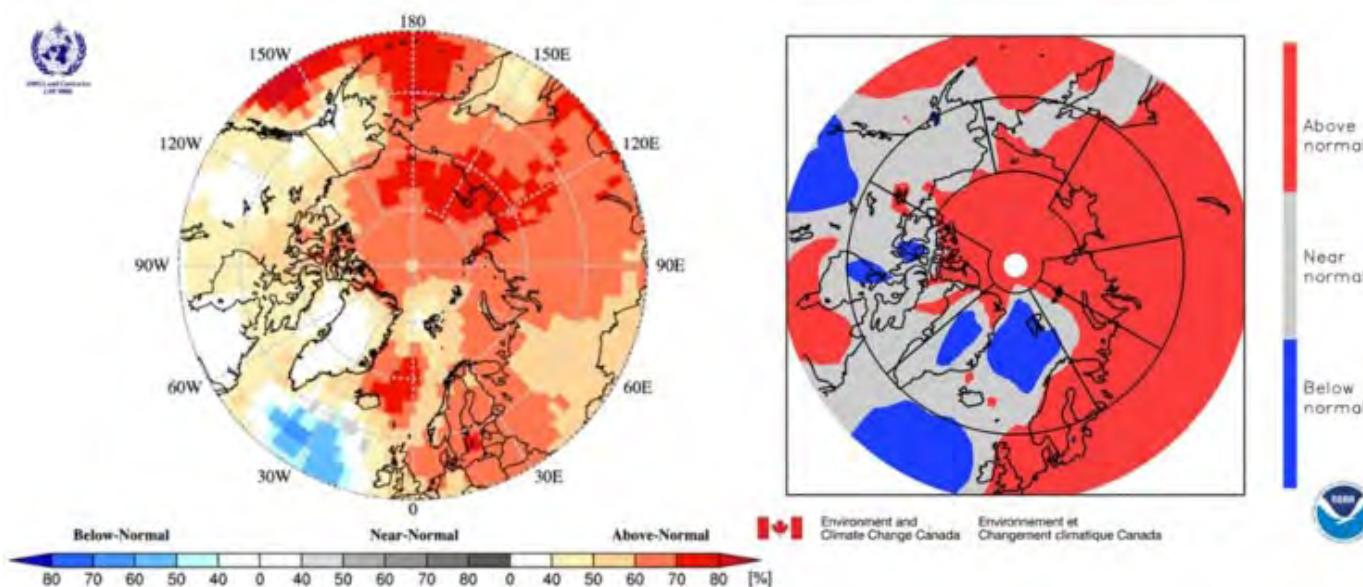


Figure 3. Left) Multi-model ensemble (MME) probability forecast for surface air temperatures: February, March, and April 2020. Three categories: below normal (blue), near normal (grey), above normal (red); no agreement amongst the models is shown in white. Source: www.wmloc.org.

Right): NCAR (National Center for Atmospheric Research) Climate forecast System Reanalysis (CFSR) for air temperature for February, March, and April 2020.

Article: 2020 Temperature & Precipitation Arctic Outlook

The FMA 2020 temperature forecast was verified by subjective comparison between the forecast (Figure 3, left) and re-analysis (Figure 3, right), region by region. A re-analysis is produced using dynamical and statistical techniques to fill gaps when meteorological observation are not available.

Above-normal surface air temperatures over the European, Eastern Siberia, Western Siberia, and Central Arctic regions were accurately forecast for the FMA 2020 season (Figure 3, Table 1). The forecast accuracies were variable over the Atlantic region, but near-normal temperatures over Iceland and parts of Greenland were accurately forecast. The observed near-normal temperatures over Alaska and the majority of Canada (grey areas on Figure 3, right) were not accurately forecast. Similarly, the observed below-normal temperatures over the Norwegian Sea and parts of Greenland (blue areas on Figure 3, right) were not accurately forecast. As a general conclusion, the multi-model ensemble forecast was accurate for approximately 50-60% of the Arctic territory.

Regions (see Figure 1)	MME Temperature Forecast Agreement	MME Temperature Forecast	NCAR CFSR Reanalysis (observed)	MME Temperature Forecast Accuracy
Alaska	Low	Above normal	Near normal	Low
Chukchi	High	Above normal	Above to near normal	Moderate
Eastern Siberia	High	Above normal	Above normal	High
Western Siberia	High	Above normal	Above normal	High
European	Moderate	Above normal	Above normal	High
Atlantic	Moderate	Mostly near normal	Above normal (Scandinavia only)	Moderate
Canada	Low	Above normal	Near to below normal	Low
Central Arctic	High	Above normal	Above normal	High

Table 1. February, March, April 2020: Regional Comparison of Observed and Forecasted Arctic Temperature

Outlook for June, July, and August 2020:

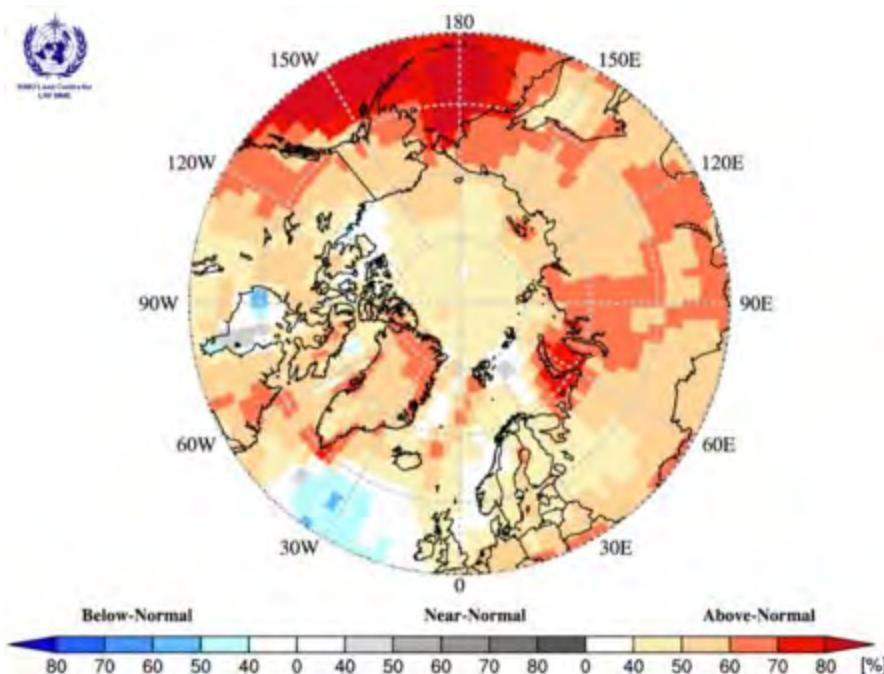


Figure 4. Multi model ensemble probability forecast for surface temperature for June, July, and August 2020. Three categories: below normal (blue), near normal (grey), above normal (red) and no agreement amongst the models (white). Source: www.wmoc.org.

Surface air temperatures during summer 2020 (JJA: June, July, and August 2020) are forecast to be above normal across the majority of the Arctic regions (orange and red areas in Figure 4). The confidence of the forecast is low to moderate over the majority of the continental Arctic (land areas) (yellow and orange areas in Figure 4, Table 2), while forecast confidences are high for the maritime parts of the Atlantic region, the Bering Sea, and a portion of the Barents and Kara Seas (dark red areas in Figure 4, Table 2). The multi-model ensemble did not agree over a few maritime areas across the Arctic (white areas in Figure 4).

Article: 2020 Temperature & Precipitation Arctic Outlook

Region (see Figure 1)	MME Temperature Forecast Agreement*	MME Temperature Forecast
Alaska	Moderate	Above normal
Chukchi	High	Above normal
Eastern Siberia	Moderate	Above normal
Western Siberia	Moderate	Above normal
European	Moderate	Above normal
Atlantic	Moderate	Above normal
Canada	Low to moderate	Above normal (below for Hudson Bay)
Central Arctic	Low to moderate	Above normal

Table 2. Summer (JJA) 2020 Outlook: Regional Forecasts for Arctic Temperatures

PRECIPITATION

Summary for February, March, and April 2020:

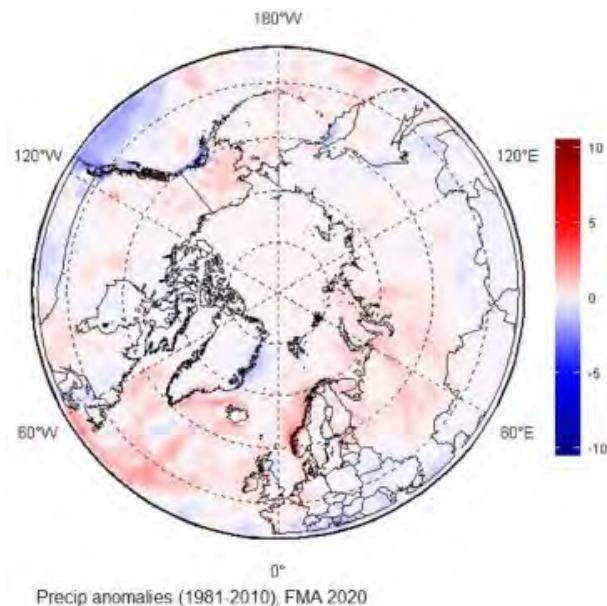


Figure 5. February, March, and April (FMA) 2020 precipitation based on the 1981-2010 reference period. Red indicates wetter than normal conditions, and blue indicates drier than normal conditions. Map produced by the Arctic and Antarctic Research Institute <http://www.aari.ru>. Data source: ERA5.

The confidence of the forecast is low (light green areas in Figure 7, Table 4). A low confidence for below normal conditions is forecasted for a portion of Northern Atlantic (light orange areas in Figure 7, Table 4). The multi-model ensemble did not agree over the remainder of the Arctic region (white areas in Figure 7).

Wetter than average conditions were observed during February, March, and April (FMA) 2020 across the majority of Arctic region (red areas in Figure 5). Only a few isolated areas, including the northeastern coast of Greenland, northern Canada, and a small swath over southern Alaska, experienced drier than average conditions (blue areas in Figure 5).

The FMA 2020 precipitation forecast was verified by subjective comparison between the forecast (Figure 6, left) and re-analysis (Figure 6, right), region by region. As for temperature, precipitation re-analysis is produced using statistical techniques to fill gaps when meteorological observation are not available.

Above-normal precipitation over the majority of the Arctic were accurately forecast for the FMA 2020 season (Figure 6, Table 3). The only exception was the Chukchi area, where observed near-normal precipitation were inaccurately forecast. There was no agreement amongst the models over the Eastern Canada and Central Arctic region (predominance of white areas over those regions). As a general conclusion, the multi-model ensemble forecast was accurate for approximately 70% of the Arctic territory.

Outlook for June, July, and August 2020:

Precipitation during summer 2020 (JJA: June, July, and August 2020) is forecast to be above normal over Alaska, and portions and the Chukchi, Eastern Siberia, and northern Canadian region; the

Article: 2020 Temperature & Precipitation Arctic Outlook

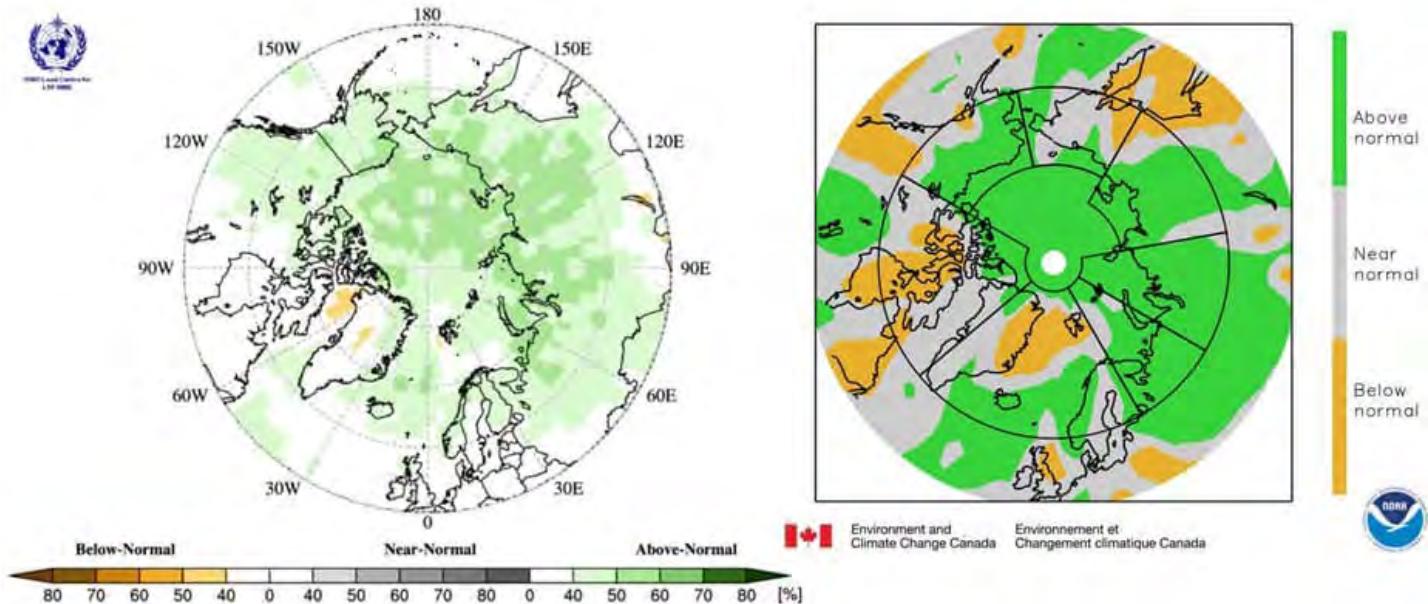


Figure 6. (Left) Multi-model ensemble (MME) probability forecast for precipitation: February, March, and April 2020. Three categories: below normal (brown), near normal (grey), above normal (green); no agreement amongst the models is shown in white. Source: www.wmoc.org. (Right): NCAR CFSR for precipitation for February, March, and April 2020.

Background and Contributors

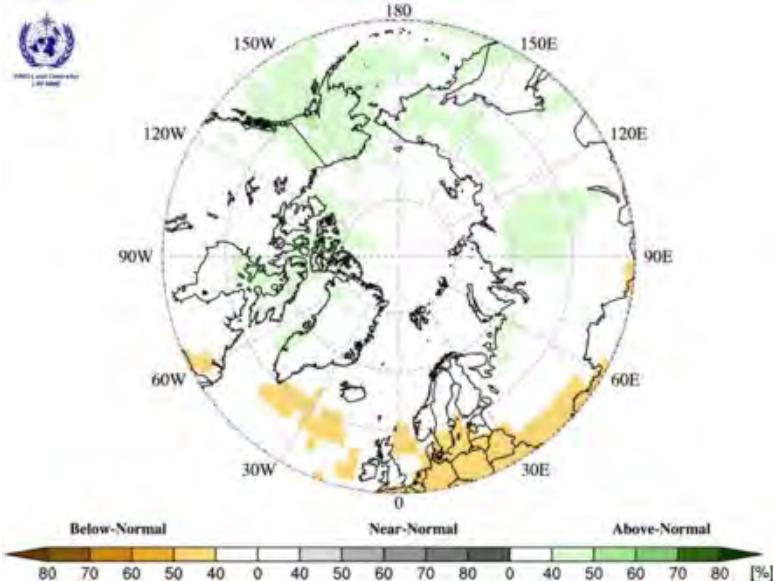


Figure 7. Multi model ensemble probability forecast for precipitation for June, July, and August 2020. Green indicates wetter conditions, orange drier conditions and white, no agreement amongst the models. Source: www.wmoc.org. Table 4. Summer (JJA) 2020 Outlook: Forecasted Arctic Precipitation by Region.

*: See non-technical regional summaries for greater detail

This Arctic seasonal climate outlook was prepared for ACF-5. Contents and graphics were prepared in partnership with the Russian, United States, Canadian, Norwegian, Danish, Finnish, Swedish, and Icelandic meteorological agencies and contributions of the former JCOMM Expert Team on Sea-ice, former CCI/CBS Inter-Programme Expert Team on Regional Climate Activities, the GCW, the IICWG, and with input from AMAP.

The ArcRCC-Network, a collaborative arrangement with formal participation by all the eight Arctic Council member countries, is in demonstration phase to seek designation as a WMO RCC-Network, and its products and services are in development and are experimental. For more information, please visit <https://arctic-rcc.org/acf-spring-2020>.

Article: 2020 Temperature & Precipitation Arctic Outlook

Regions (see Figure 1)	MME Precipitation Forecast Agreement	MME Precipitation Forecast	NCAR CFSR Reanalysis (observed)	MME Precipitation Forecast Accuracy
Alaska	Moderate	Above normal	Above normal	High
Chukchi	Moderate	Above normal	Near normal	Low
Eastern Siberia	Moderate	Above normal	Above normal	High
Western Siberia	Moderate	Above normal	Above normal	High
European	Moderate	Above normal	Above normal	High
Atlantic	Moderate	Above normal (continental regions only)	Above normal (continental regions only)	High
Canada	No agreement	No forecast	Near normal in the south and west, below in the center	N/A
Central Arctic	No agreement	No forecast	N/A	N/A

Table 3. February, March, April 2020: Regional Comparison of Observed and Forecasted Arctic Precipitation

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- Anahit Hovsepyan, Rupa Kumar Kolli (WMO)
- Arun Kumar and Shanna Combley (Climate Prediction Center, National Oceanic and Atmospheric Administration, USA)

Acronym List

AARI: Arctic and Antarctic Research Institute

ArcRCC-Network: Arctic Regional Climate Centre Network

ACF: Arctic Climate Forum

AMAP: Arctic Monitoring and Assessment Programme

CCI: WMO Commission for Climatology/

CBS: WMO Commission for Basic Systems

GCW: Global Cryosphere Watch

GPCs-LRF: WMO Global Producing Centres Long-Range Forecasts

IICWG: International Ice Charting Working Group

LC-LRFMME: WMO Lead Centre for Long Range Forecast Multi-Model Ensemble

NCAR: National Center for Atmospheric Research

NCAR CFSR: National Center for Atmospheric Research Climate Forecast System Reanalysis

NOAA/NWS/NCEP/CPC: National Oceanic and Atmospheric Administration/National Weather Service/National Centers for Environmental Prediction/Climate Prediction Center (United States of America)

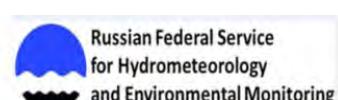
MME: Multi-model ensemble

RCC: Regional Climate Outlook Forum

WMO: World Meteorological Organization



Icelandic Met
Office



ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE



Environment and
Climate Change Canada



Arctic Climate Forum

Article: Summer Arctic Sea-Ice Outlook

2020 Arctic Summer Seasonal Climate Outlook for Sea-Ice

By contributors from Environment and Climate Change Canada, the University of Québec at Montréal, the Arctic and Antarctic Research Institute, the Hydrometeorological Centre of Russia, The Norwegian Meteorological Institute, Finnish Meteorological Institute, World Meteorological Organization, Climate Prediction Center, and National Oceanic and Atmospheric Administration

Arctic Climate Forum Consensus Statement (Continued)

Highlights

Warmer than normal surface air temperatures over Eurasia and the Arctic Ocean contributed to below to near normal ice conditions during the 2019-2020 winter across the entire Arctic. Forecast variability in above normal temperatures and wetter-than-average conditions across the different Arctic regions for June–August 2020 are contributing to the spatial variability in spring break-up and minimum sea ice extent forecast for the summer of 2020.

Sea-ice

The Northern Hemisphere March 2020 maximum sea-ice extent was the 11th lowest since 1979. Earlier than normal spring break-up is expected for the majority of the regions across the Arctic, with the exception the Barents Sea, Greenland Sea, and the eastern half of Hudson Bay, where a later than normal spring break-up is expected. Below normal 2020 minimum sea ice extent are forecast for majority of the Arctic regions; exceptions are above normal conditions forecast for the Barents and Greenland Seas.

Understanding the Consensus Statement

This consensus statement includes: a seasonal summary and forecast verification for sea-ice for previous 2020 Arctic winter season (February, March, and April 2020); an outlook for the upcoming 2020 Arctic summer season (June, July, and August 2020). Figure 1 shows the established shipping routes and regions used for the sea-ice products.

The sea ice extent and experimental freeze-up forecasts are based on the Canadian Seasonal to Inter-annual Prediction System (CanSIPSv2), a multi model ensemble (MME) of two climate models. A larger multi-model ensemble that will include forecasts from the following WMO GPC-LRFs is under development: ECCC/MSC (CanSIPSv2), NOAA (CFSv2), Meteo-France (System 5), UK MetOffice (GloSea5) and ECMWF (SEAS5). When sea ice extent is at its minimum in September of each year, forecasts are available for the following peripheral seas where there is variability in the ice edge: Barents Sea, Beaufort Sea, Canadian Arctic Archipelago, Chukchi Sea, Eastern Siberian Sea, Greenland Sea, Kara Sea, and Laptev Sea. In addition to these regions, forecasts for sea ice break-up are also available for Baffin Bay, Bering Sea, East Siberian Sea, Kara Sea, Laptev Sea, Chukchi Sea, Barents Sea, Greenland Sea, Hudson Bay, and Labrador Sea. Summer outlooks for key shipping areas are provided by the Arctic and Antarctic Research Institute, Canadian and Finnish ice services, and are based on statistical model guidance and forecast expertise.



Figure 1. Sea-Ice Regions. Map Source: Courtesy of the U.S. National Academy of Sciences.

Sea-Ice and Arctic Ocean

In general, high positive sea surface temperature (SST) anomalies and prevailing positive polar ocean upper layer (15m) heat content (HC) during October-December 2019 (MERCATOR Ocean reanalysis, not shown here) slowed freeze-up and sea ice growth in the Arctic. Weaker positive SST anomalies and neutral HC anomalies between January and March 2020 stimulated ice extent growth over the most of the Arctic region, while strong negative HC anomalies lead to close to normal ice growth in the Northern Barents Sea, Bering Sea and Sea of Okhotsk (Figure 2).

Article: Summer Arctic Sea-Ice Outlook

The 15.1 mln km² maximum sea-ice extent reached on March 5, 2020 is the 11th lowest maximum sea-ice extent since 1979 (2019 – 7th), with the maximum winter sea ice extent observed in 1979 (16.77 mln km²). Nevertheless, estimates of the sea ice volume based on numerical reanalysis (HYCOM-CICE, PIOMAS) show that the 2020 sea ice volume was similar to that of 2019, a year with one of the lowest sea ice volume on records. Similarly, maximum winter ice

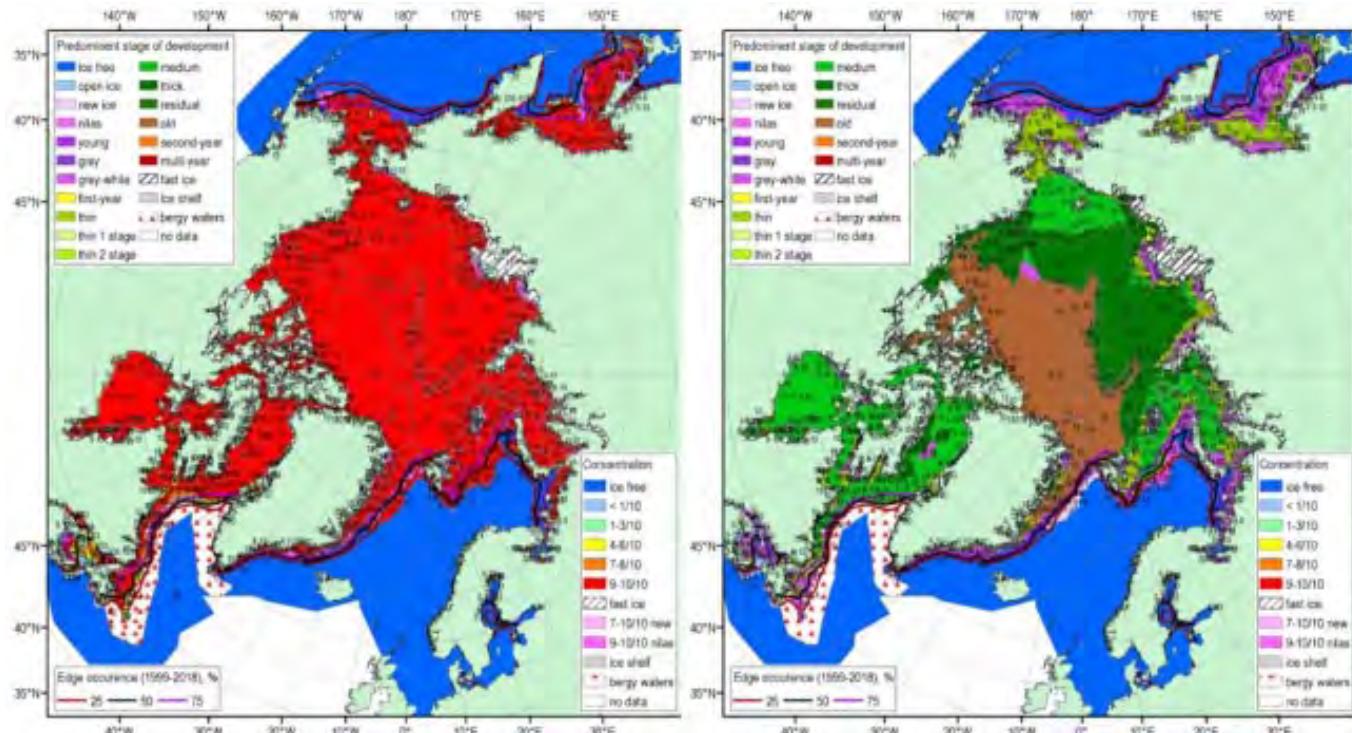


Figure 2. Blended Arctic ice chart (AARI, CIS, NIC) for 16-19 March 2020 and ice edge occurrences for 16-20 March for 1999-2018. Left: total concentration, right: predominant stage of development

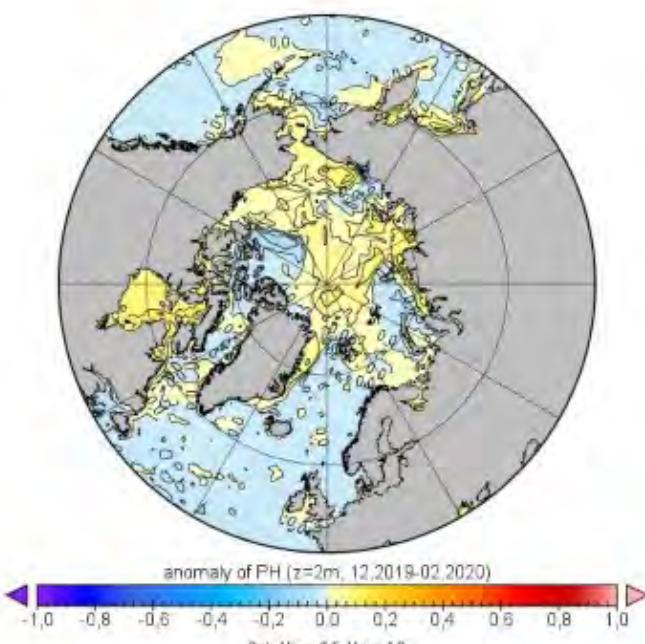


Figure 3. pH 2m depth anomalies in December 2019, January 2020, and February 2020 relative to 2000-2019. Map produced by the Arctic and Antarctic Research Institute <http://www.aari.ru>. Data source: Copernicus Marine Service.

thicknesses observed at coastal stations were in general significantly thinner on the Siberian side of the Arctic (up to – 50 cm for Kara Sea).

The effects of changing sea ice conditions in the boundary seas of the Arctic Ocean for winter 2020 included warmer and stormier weather conditions in the majority of the Arctic region, with the exceptions of Svalbard and Northern Greenland area who experienced colder and calmer conditions than normal.

Figure 3 shows the MERCATOR Ocean pH anomalies for winter 2020, where areas of both positive (yellow areas: Arctic Basin and Chukchi Sea) and negative pH (blue areas: Barents, Kara Sea, and Canadian Arctic) anomalies can be identified. Such pH anomalies indicate possible effects of the different alkalization and acidification processes to Arctic marine wildlife.

The forecast for March 2020 sea ice extent (Figure 4) was based on output from CanSIPSv2, an MME of two climate models and verified reasonably well for the Greenland Sea, the Gulf of St. Lawrence, and the Labrador Sea. Two regions, the Gulf of St. Lawrence and the Sea of Okhotsk, had a high forecast accuracy (right column, Table 1).

Article: Summer Arctic Sea-Ice Outlook

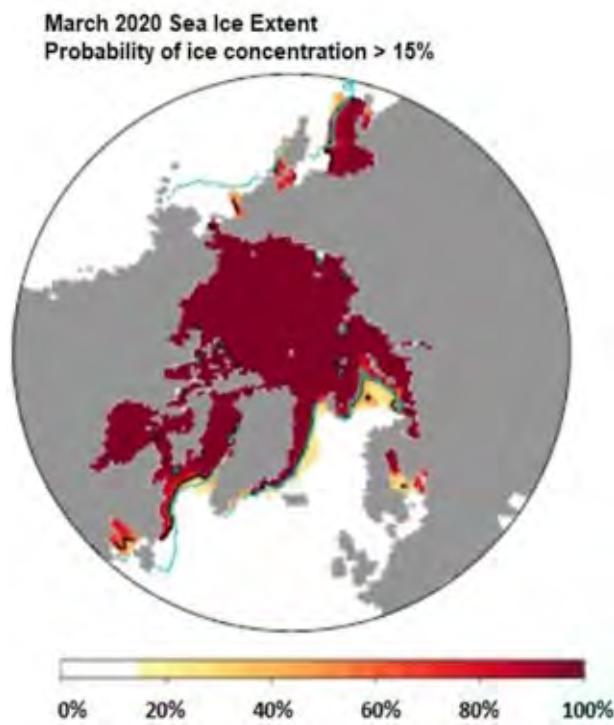


Figure 4. March 2020 probability of sea ice at concentrations greater than 15% from CanSIPS (ECCC). Forecast mean ice extent (black) and observed mean ice extent 2009-2017 (green).

Above normal air temperatures in Davis Strait and over the northern Labrador Coast suppressed ice growth during the past winter, leading to significantly lower ice export from these regions southward along the Labrador Coast and into the northwestern section of the Gulf of St. Lawrence. A near normal temperature regime was observed over the Gulf of St. Lawrence, but the lack of sea ice contributions from northern regions led to a lower than normal ice extent for the Gulf. Pronounced warm air temperature and low surface level pressure anomalies over the Barents and Greenland Seas for winter 2019-2020 restricted sea ice development as ice expansion was slowed by the lack of deep, sustained cold and the presence of regular destructive wind events. Relatively normal surface pressure and air temperature patterns over the Bering Sea and the Sea of Okhotsk supported near normal ice coverages.

Outlook for Spring Break-up 2020

Sea ice break-up is defined as the first day in a 10-day interval where ice concentration falls below 50% in a region. The outlook for spring break-up shown in Figure 5 displays the sea ice break-up anomaly from CanSIPsV2 based on the nine-year climatological period from 2011-2019. The qualitative 3-category (high, moderate, low) confidence in the forecast is based on the historical model skill. Only regions where the model has historical skill are included in the outlook (Figure 6). A summary of the forecast for the 2020 spring break-up for the different Arctic regions is shown in Table 2.

Outlook for September 2020 Minimum Sea Ice Extent

Minimum sea ice extent is achieved each year during the month of September in the northern hemisphere. Table 3 categorizes the

Regions (see Figure 2)	CanSIPS Sea-Ice Forecast Confidence	CanSIPS Sea-Ice Forecast	Observed Ice Extent	CanSIPS Sea-Ice Forecast Accuracy
Bering Sea	Low	Below normal	Normal	Low
Sea of Okhotsk	Low	Below to near normal	Below to near normal	High
Barents Sea	Low	Near normal	Below normal	Low
Greenland Sea	High	Near normal	Below to near normal	Moderate
Gulf of St. Lawrence	Low	Below normal	Below to near normal	High
Labrador Sea	Moderate	Below normal	Below to near normal	Moderate

Table 1. Winter 2019-2020: Regional Comparison of Observed and Forecasted Maximum Sea-Ice Extent.

sea ice extent forecast confidence and relative extent (i.e. near normal, below normal, above normal) with respect to a 2011-2019 climatology by Arctic region. Figure 7 displays the probabilities of ice presence for concentrations greater than 15% and the forecasted mean ice extent from CanSIPsV2 (black), with the observed median ice extent for the 2011-2019 period in red. The sea ice extent is expected to be below normal for the Beaufort Sea, Canadian Arctic Archipelago, Chukchi Sea, East Siberian Sea, Kara Sea and Laptev Sea, and above normal for the Barents and Greenland Seas.

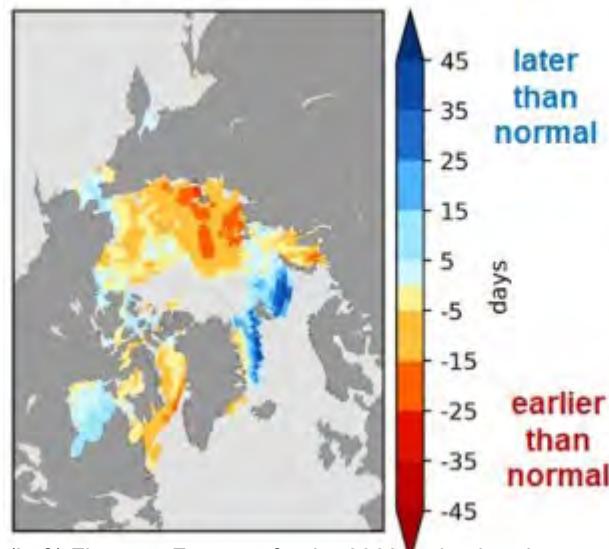
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Above normal air temperatures in Davis Strait and over the northern Labrador Coast suppressed ice growth during the past winter, leading to significantly lower ice export from these regions southward along the Labrador Coast and into the northwestern section of the Gulf of St. Lawrence. A near normal temperature regime was observed over the Gulf of St. Lawrence, but the lack of sea ice contributions from northern regions led to a lower than normal ice extent for the Gulf. Pronounced warm air temperature and low surface level pressure anomalies over the Barents and Greenland Seas for winter 2019-2020 restricted sea ice development as ice expansion was slowed by the lack of deep, sustained cold and the presence of regular destructive wind events. Relatively normal surface pressure and air temperature patterns over the Bering Sea and the Sea of Okhotsk supported near normal ice coverages.

Outlook for Spring Break-up 2020

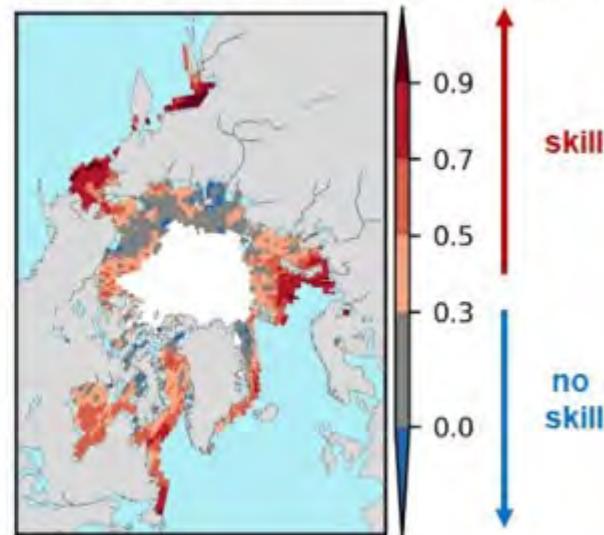
Break-up Date Anomaly

Climatology Period 2011-2019



Historical Forecast Skill

Detrended anomaly correlation coefficient 1981-2019



(Left) Figure 5. Forecast for the 2020 spring break-up expressed as an anomaly (difference from normal), where break-up is defined as the date when the ice concentration drops below 50%.

(Right) Figure 6. Historical forecast skill defined as the detrended anomaly correlation coefficient based on the 1981-2019 period.

Regions (see Figure 2)	CanSIPSv2 Sea-Ice Forecast Confidence	CanSIPSv2 Sea-Ice Break- up Forecast
Baffin Bay	High	Early
Barents Sea	High	Late in northern section
Beaufort Sea	High	Early
Bering Sea	Moderate	Near normal to late
Chukchi Sea	High	Early
East Siberian	Low	Early southern section, near normal northern section
Greenland Sea	High	Late
Hudson Bay	Moderate	Late eastern half, near normal western half
Kara Sea	Moderate	Early in the west, near normal in the east
Labrador Sea	High	Early
Laptev Sea	Low	Early

Table 2. Spring 2020 Regional Outlook for Arctic Sea Ice Break-up

Sea ice break-up is defined as the first day in a 10-day interval where ice concentration falls below 50% in a region. The outlook for spring break-up shown in Figure 5 displays the sea ice break-up anomaly from CanSIPSv2 based on the nine-year climatological period from 2011-2019. The qualitative 3-category (high, moderate, low) confidence in the forecast is based on the historical model skill. Only regions where the model has historical skill are included in the outlook (Figure 6). A summary of the forecast for the 2020 spring break-up for the different Arctic regions is shown in Table 2.

Outlook for September 2020 Minimum Sea Ice Extent

Minimum sea ice extent is achieved each year during the month of September in the northern hemisphere. Table 3 categorizes the sea ice extent forecast confidence and relative extent (i.e. near normal, below normal, above normal) with respect to a 2011-2019 climatology by Arctic region. Figure 7 displays the probabilities of ice presence for concentrations greater than 15% and the forecasted mean ice extent from CanSIPSv2 (black), with the observed median ice extent for the 2011-2019 period in red. The sea ice extent is expected to be below normal for the Beaufort Sea, Canadian Arctic Archipelago, Chukchi Sea, East Siberian Sea, Kara Sea and Laptev Sea, and above normal for the

Article: Summer Arctic Sea-Ice Outlook

the Barents and Greenland Seas.

Regions (see Figure 2)	CanSIPSV2 Sea-Ice Extent Forecast	CanSIPSV2 Sea- Ice extentForecast
Barents Sea	Low	Above normal (northern section)
Beaufort	Moderate	Below normal
Canadian Arctic Archipelago	Moderate	Below normal
Chukchi Sea	High	Below normal
Eastern Siberian Sea	Moderate	Below normal
Greenland Sea	High	Above normal
Kara Sea	High	Below normal
Laptev Sea	High	Below normal

Table 3. Summer 2020 Regional Outlook for Minimum Sea-Ice Extent

Outlook for Key Shipping Regions

Figure 7. September 2020 probability of sea ice at concentrations greater than 15% from CanSIPSV2 (ECCC). Forecast median ice extent from CanSIPSV2 (black) and observed mean ice edge 2011-2019 (red).

Northern Sea Route (NSR): Ice conditions are not expected to be problematic for the whole of the NSR during the spring and summer seasons in 2020. Currently observed below normal ice conditions, and projected above normal air temperatures and earlier than normal sea ice deterioration form the basis for this assessment. Light ice conditions will prevail throughout the sector and areas of landfast ice will break-up earlier than normal. Significant incursions of old ice are not expected along the route this summer season.

Northwest Passage: Break-up of sea ice is expected to be earlier than normal throughout the Northwest Passage this summer, and areas of consolidated ice will become mobile earlier in the season than normal. Ice conditions will be light in the southern route of the Northwest Passage in August 2020, with lessening ice conditions following in northern route by early September 2020. Anomalous concentrations of old ice are a potential portion of the passage, as higher than normal amounts of old sea ice are present in these areas. Enhanced mobility of sea ice in the Canadian Arctic Archipelago could maintain elevated old ice concentrations in the aforementioned sectors throughout the summer 2020 period.

— observed mean ice edge (2011-2019)
— forecast median ice edge

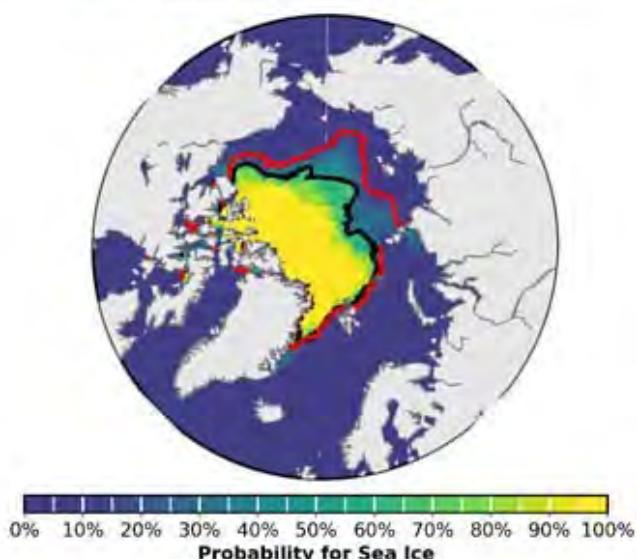


Figure 7. September 2020 probability of sea ice at concentrations greater than 15% from CanSIPSV2 (ECCC). Forecast median ice extent from CanSIPSV2 (black) and observed mean ice edge 2011-2019 (red).

Baffin Bay: Early than normal sea ice break-up is forecasted for Baffin Bay this summer, due to current lower than normal ice extents in the region and predicted warmer than normal temperatures in the area of interest. Old ice concentrations in the bay are in line with climatological normal, and no specific hazards are anticipated. The presence of an ice bridge in Nares Strait well into this spring has cut off the inflow of old ice from the Arctic Ocean into northern Baffin Bay, thereby maintaining a limited influx of old ice into the region.

Hudson Bay/Hudson Strait: Faster than normal sea ice break-up is underway in Hudson Strait with significant areas of open water expanding in the northern portion of the strait this spring. Projections for ice break-up in Hudson Bay are more delayed than for the Hudson Strait, with near normal break-up expected for the western portion of the bay, and later than normal break-up in the eastern section. Ice thicknesses throughout Hudson Bay are notably thicker this spring than those observed in spring 2019, as predominantly thick first-year ice covers the western and central portions of the bay while in 2019, medium first-year ice comprised a significant fraction of the ice cover. This thicker ice coverage along with forecasted colder than normal surface air temperatures over Hudson Bay could lead to a more challenging navigation season, particularly in the eastern half of Hudson Bay.

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Background and Contributors

This Arctic seasonal climate outlook was prepared for ACF-5. Contents and graphics were prepared in partnership with the Russian, United States, Canadian, Norwegian, Danish, Finnish, Swedish, and Icelandic meteorological agencies and contributions of the former JCOMM Expert Team on Sea-ice, former CCI/CBS Inter-Programme Expert Team on Regional Climate Activities, the GCW, the IICWG, and with input from AMAP.

The ArcRCC-Network, a collaborative arrangement with formal participation by all the eight Arctic Council member countries, is in demonstration phase to seek designation as a WMO RCC-Network, and its products and services are in development and are experimental. For more information, please visit <https://arctic-rcc.org/acf-spring-2020>.

Note from the Editor: this article accompanies the [2020 Arctic Seasonal Climate Outlook for Temperature and Precipitation](#), for which its introduction also applies to this piece.

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Acronyms

AARI: [Arctic and Antarctic Research Institute](#)

ArcRCC-Network: [Arctic Regional Climate Centre Network](#)

ACF: [Arctic Climate Forum](#)

AMAP: [Arctic Monitoring and Assessment Programme](#)

CCI: [WMO Commission for Climatology/](#)

CBS: [WMO Commission for Basic Systems](#)

GCW: [Global Cryosphere Watch](#)

GPCs-LRF: [WMO Global Producing Centres Long-Range Forecasts](#)

IICWG: [International Ice Charting Working Group](#)

LC-LRFMME: [WMO Lead Centre for Long Range Forecast Multi-Model Ensemble](#)

NCAR: [National Center for Atmospheric Research](#)

NCAR CFSR: [National Center for Atmospheric Research Climate Forecast System Reanalysis](#)

NOAA/NWS/NCEP/CPC: [National Oceanic and Atmospheric Administration/National Weather Service/National Centers for Environmental Prediction/Climate Prediction Center](#) (United States of America)

MME: [Multi-model ensemble](#)

RCC: [Regional Climate Outlook Forum](#)

WMO: [World Meteorological Organization](#)



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Institute



Arctic Climate Forum

Article: Micrometeorological Variables

Micrometeorological Variables and Atmospheric Dispersion Modeling in Two Climate Regions of Quebec

By Richard Leduc, Ph.D., [AirMet Science Inc.](#), and Jean-François Brière, [Ministère de l'Environnement et de la Lutte contre les changements climatiques](#)

The US-EPA (2019a) AERMOD dispersion model is widely used to assess the concentration of contaminants in ambient air as a result of emissions from a source. To this end, AERMOD requires micrometeorological variables characterizing turbulence (u^* , w^* , L , zic , zim); they are calculated by the AERMET module and obtained using local surface and upper air data (wind, temperature and cloud opacity), the calculation details of which are in EPA (2019b). Climatic differences will thus affect these variables and influence atmospheric dispersion. Two stations (Maniwaki and Sept-Îles) located in two different climatic regions of Quebec and separated by a distance of about 800 km were selected in order to compare their micrometeorological variables and the results of the dispersion modeling from a point source emission for the 2008-2012 period. Results from this comparison are briefly presented here; more detailed results are available by contacting an author.

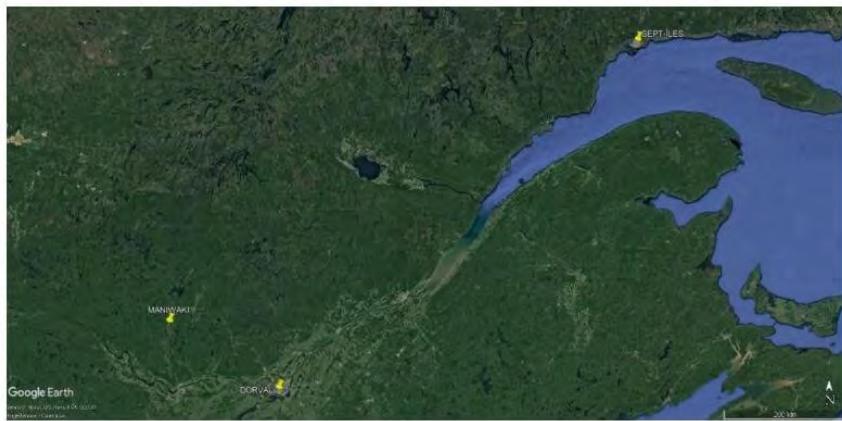
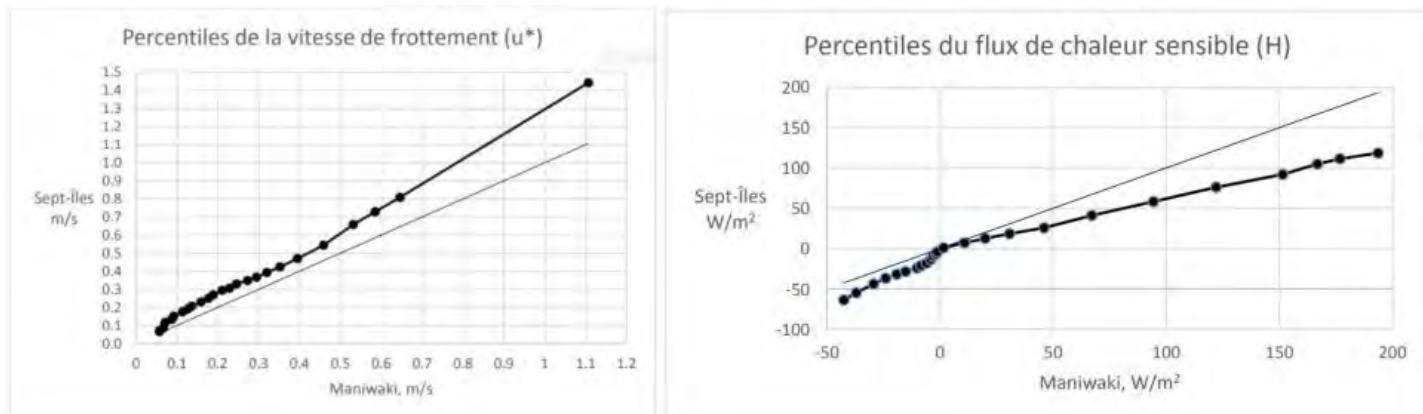


Figure 1. Dorval, Maniwaki, and Sept-Îles locations

Sept-Îles is colder than Maniwaki with an annual average of 2.8°C compared to 5.5°C . A clear sky is less frequent in Sept-Îles than in Maniwaki (17.04% vs 20.15%) and the opposite is true for a covered sky with an opacity of 10 (33.53% vs 30.54%). Excluding calm winds for which calculations are not made, the average wind speed in Sept-Îles is higher than at Maniwaki (4.49 m/s vs 2.24 m/s) and it is the same for the friction velocity (u^* ; 0.29 m/s vs 0.22 m/s); results are also compared using Q-Q plots (Figure 2 with 1st, 2nd, 5th, 10th, 15th,..., 95th, 98th, 99.5th and 100th percentiles). Percentiles for u^* are higher in Sept-Îles.

The higher latitude, the greater cloudiness and the lower temperature of Sept-Îles produce differences in the sensible heat flux (H) so that Maniwaki's average is much higher (16.47 W/m^2 vs 1.11 W/m^2); it is seen (Figure 3) that percentiles are not much different for $H < 0 \text{ W/m}^2$ (60th percentiles) but the difference gets higher after. The distribution of $1/L$ (Figure 5) show values in Sept-Îles that are much less negative than in Maniwaki up to the 45th

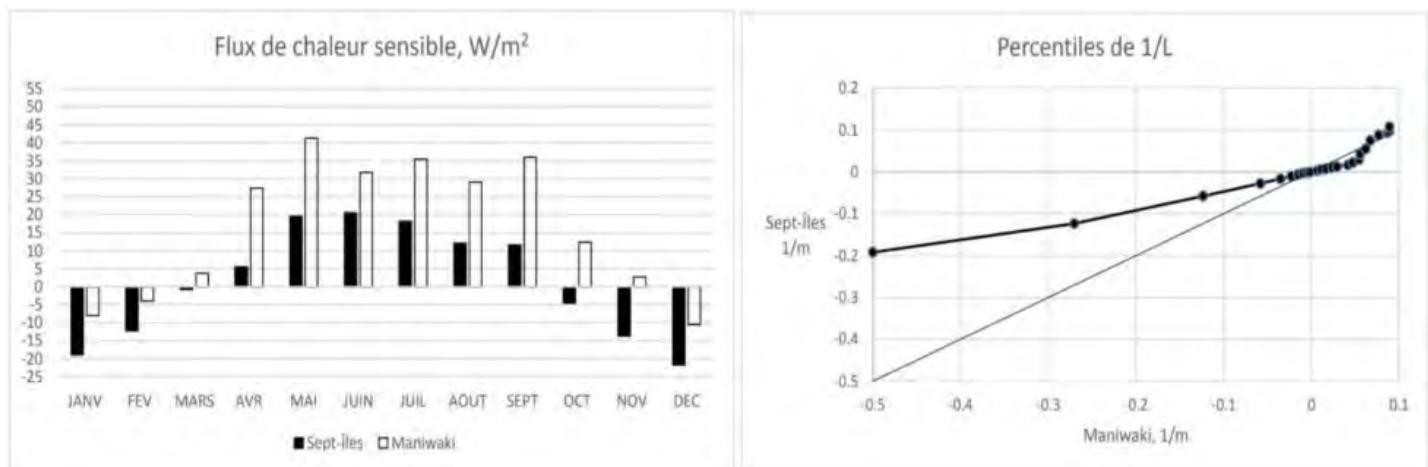


(Left) Figure 2. Percentile of shear velocity u^* (m/s) -Sept-Îles – Maniwaki

(Right) Figure 3. Sensible heat flux percentiles (W/m^2) – Sept-Îles – Maniwaki

percentile and after positive values higher in Maniwaki up to the 90th percentile and finally those of Sept-Îles are a little higher. To distinguish the between the stability conditions, a range of -0.015 m^{-1} to 0.015 m^{-1} was chosen for a neutral class; the frequency of neutral cases is 53% in Sept-Îles and 28% in Maniwaki, while convective cases ($<-0.015 \text{ m}^{-1}$) are more frequent in Maniwaki (25% vs 16%) and also for the stable cases ($> 0.015 \text{ m}^{-1}$; 46% vs 31%). These results are attributable to a windier and cloudier conditions in Sept-Îles.

Article: Micrometeorological Variables



(Left) Figure 4. Monthly sensible heat flux (W/m²)

(Right) Figure 5. Percentiles of 1/L (m⁻¹) – Sept-Îles and Maniwaki

In Maniwaki, the mean convective velocity scale (w^*) is higher than that of Sept-Îles (0.9 m/s vs 0.71 m/s) as shown also in Figure 6. The distribution of w^* in two seasons (May to September and October to April) and also in the warm season according to cloud cover opacity are quite different (Figure 7, Figure 8); similar results are obtained for Sept-Îles. The average convective mixing height is greater in Maniwaki (647.3 m vs 519.6 m) and it is the contrary for the mechanical mixing height (273.5 m vs 403.3 m); these differences are also shown in Figure 9.

The micrometeorological variables of Maniwaki and Sept-Îles are used to model (with AERMOD) the atmospheric dispersion of emissions from a point source ($h_s=15$ m, $d_s=0.5$ m, $v_s=10$ m/s, $T_s=50^\circ\text{C}$, $q_s=1$ g/s) in order to examine how they influence the concentrations calculated at 4481 receptors over the same 5 years period.

In Maniwaki, the highest hourly concentration is 103.69 µg/m³ compared to 90.43 µg/m³ in Sept-Îles (+14.7%). The average hourly maxima for all receptors is 14% higher in Maniwaki (46.83 µg/m³ vs 41.06 µg/m³). The highest 99.5 hourly percentile is 62.92 µg/m³ in Maniwaki and 47.86 µg/m³ at Sept-Îles (+31.5%) and the percentiles of the hourly maximum are higher in Maniwaki (Figure 10).

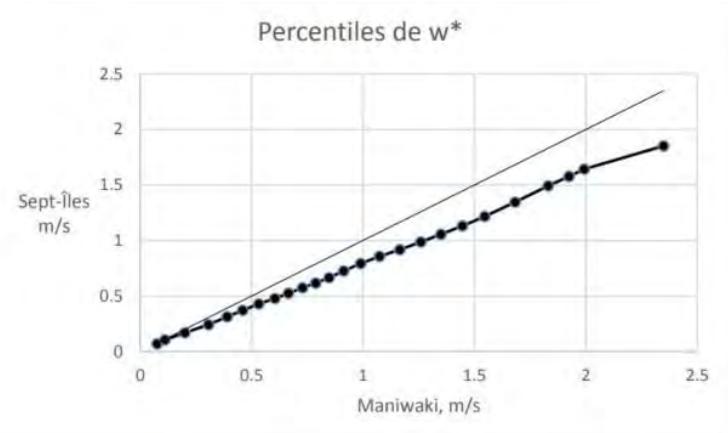


Figure 6. Percentiles of w^* (m/s) Sept-Îles and Maniwaki

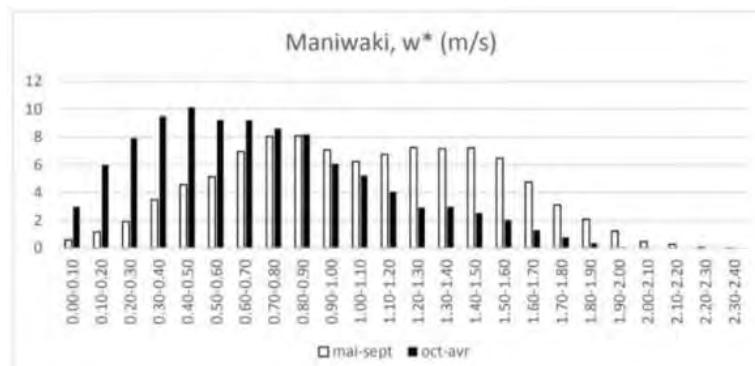
With respect to daily maxima (Figure 11), Sept-Îles is at 30.73 µg/m³ compared to 43.09 µg/m³ in Maniwaki (+40.2%); it is the same for the mean and the median (+55.7%, +44.5%).

The maximum mean of the period is 3.45 µg/m³ in Sept-Îles and 4.29 µg/m³ in Maniwaki (+24.3%); over all receptors, Maniwaki has a mean 83% higher (0.97 µg/m³ vs 0.53 µg/m³) and the median is 31.1% higher (0.59 µg/m³ vs 0.45 µg/m³); Figure 12 also shows the greater difference between the two places.

For all receptors, hourly maximum concentrations in Sept-Îles are mostly associated with neutral conditions (about 41%), while in Maniwaki it's mostly stable conditions (about 47%), which may be the cause of its more elevated concentrations calculated there.

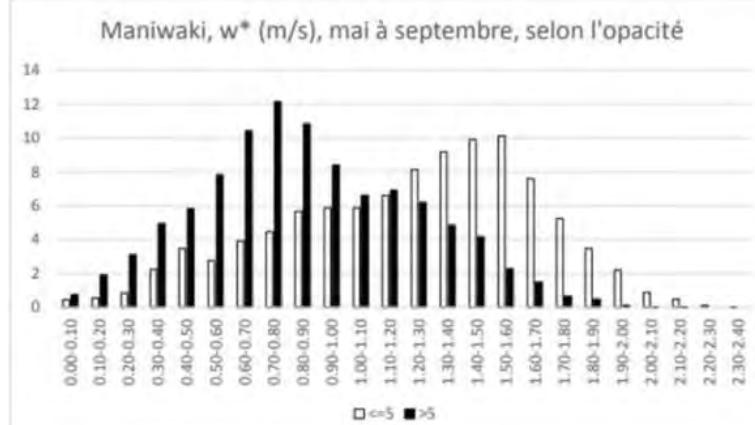
In conclusion, the impact of climatic differences between Dorval and Sept-Îles on micrometeorological variables has been quantified, which in turn produced different dispersion modeling calculation results. Different results could also be obtained for other source types, such as surface sources and other local conditions such as topography.

Article: Micrometeorological Variables



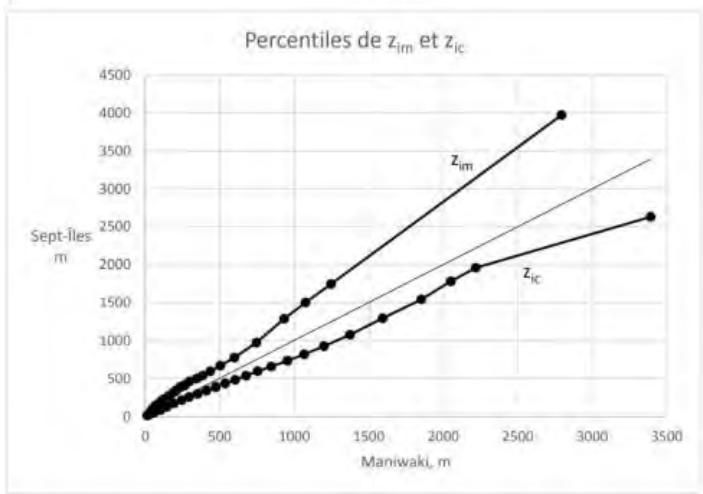
(Top) Figure 7. Histogram of w^* in Maniwaki for two seasons

(Bottom) Figure 8. Histogram of w^* in Maniwaki during the warm season (May to September) based on opacity.



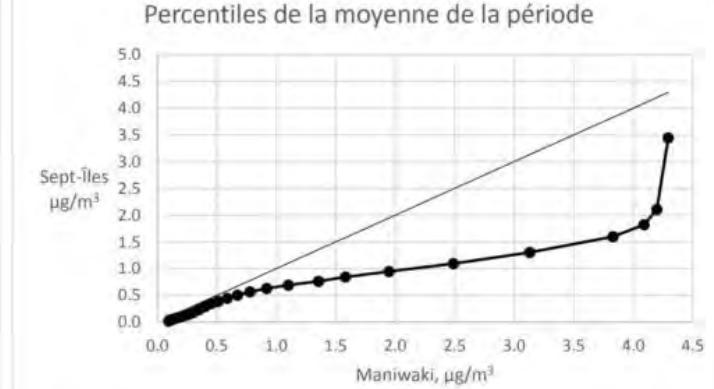
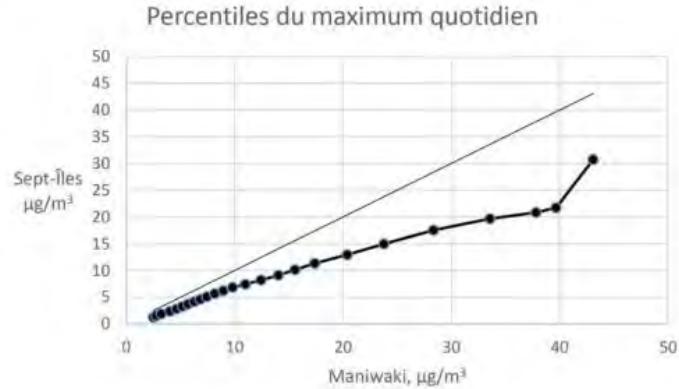
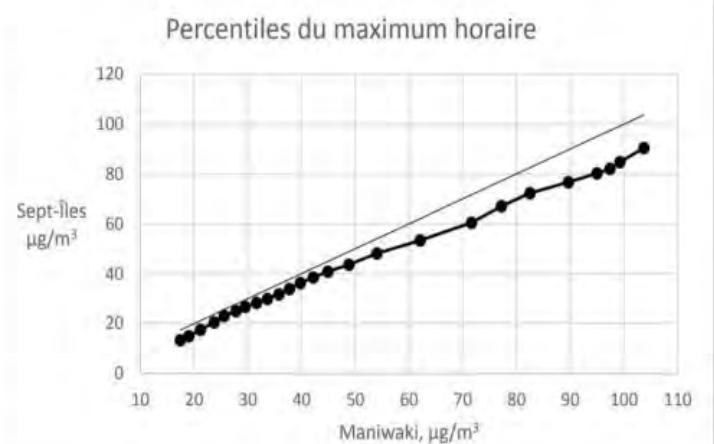
(Left) Figure 9. Percentiles of z_{im} (m)

(Right) Figure 10. Percentiles of hourly maximum concentrations



(Bottom left) Figure 11. Percentiles of daily maximum concentrations

(Bottom right) Figure 12. Percentiles of mean concentrations for the time frame



Article: Micrometeorological Variables

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We express our sincere thanks to M. Philippe Barnéoud, Environment and Climate Change Canada, for his advice and comments and Lakes Environmental for the usage of AERMOD-View.

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Article: A Note on ECCC Radar Snowfall Estimates

A Note on ECCC Radar Snowfall Estimates and Radar Data

By Diar Hassan (Wood PLC, Ottawa ON), George Isaac (Weather Impacts Consulting Inc., Barrie ON), Peter Taylor (York University, Toronto ON), Daniel Michelson (Environment and Climate Change Canada – ECCC), and Norman Donaldson (ECCC).

It often snows in Newfoundland but on 17 January 2020, it was a little extreme (Figure 1). METAR reports from St John's airport, CYYT, indicated 35 cm of snow fell between 1200-1800 UTC and another 19 cm in the next 6 hours. These snowfall depth measurements are consistent with many others in the area.

The 10-min historical images from the Holyrood radar can be accessed from Environment and Climate Change Canada (ECCC) (Figure 2). Please note the blockage to the south of the radar and the exaggerated reflectivity due to clutter at the Conception Bay area, to the north of the radar, should be ignored. From the images, the estimated snowfall at CYYT for that 12 h period is only 16.5 cm, typically at rates of 1 or 2 cm h⁻¹. This is too low.

Reflectivity (Z), Equivalent Reflectivity (Z_e), and Snowfall Rate Equivalent Reflectivity (Z_{es})

ECCC radar images display the solid snowfall rates in cm h⁻¹ during the winter season, based on the assumption that the solid snow to liquid ratio is 10:1, so that 1 mm h⁻¹ of snow water equivalent (SWE) corresponds to 1 cm h⁻¹ of solid snow. The reflectivity values (dBZ) being displayed on the ECCC radar images (in Figure 2) are ($Z_e+6.5$ dBZ) and will hereafter be called Z_{es} .



Figure 1. A street in St John's, NL, January 17, 2020.

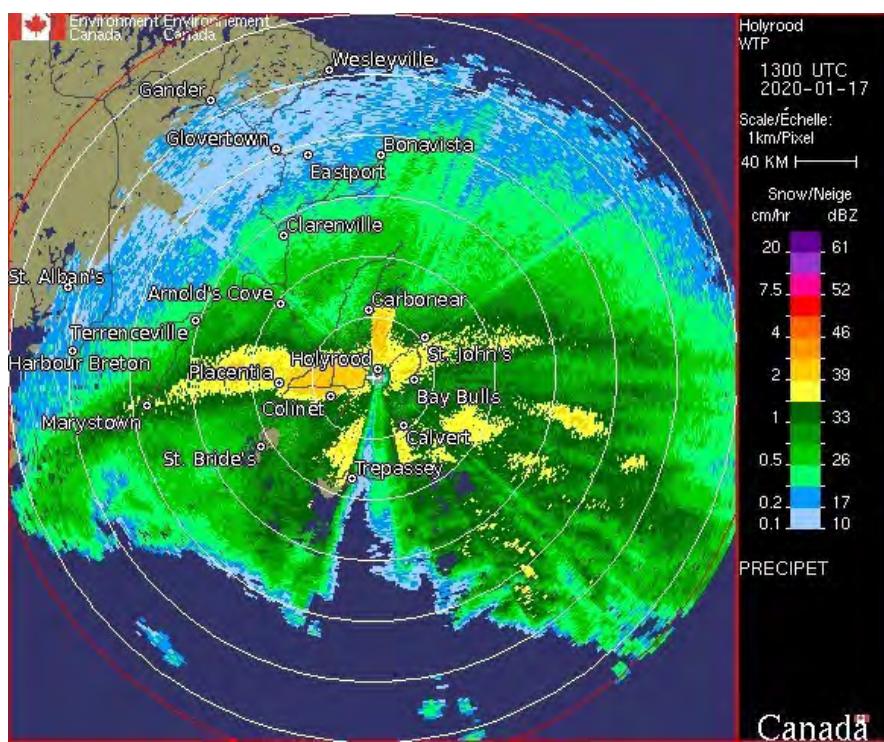


Figure 2. Holyrood radar (PRECIPET CAPPI) for 1300 UTC on January 17, 2020, downloaded from ECCC historical radar site.

forms of mixed precipitation, there is uncertainty about K. In practice, the liquid water value, K_w , is used and a corresponding, Z_e , value is referred to as the “equivalent reflectivity factor”. For snow, Z_e is significantly smaller than the true Z because of the ratio of ($|K_i|^2/|K_w|^2$) but the ice/water density difference is also a factor since Z is defined in terms of melted diameters.

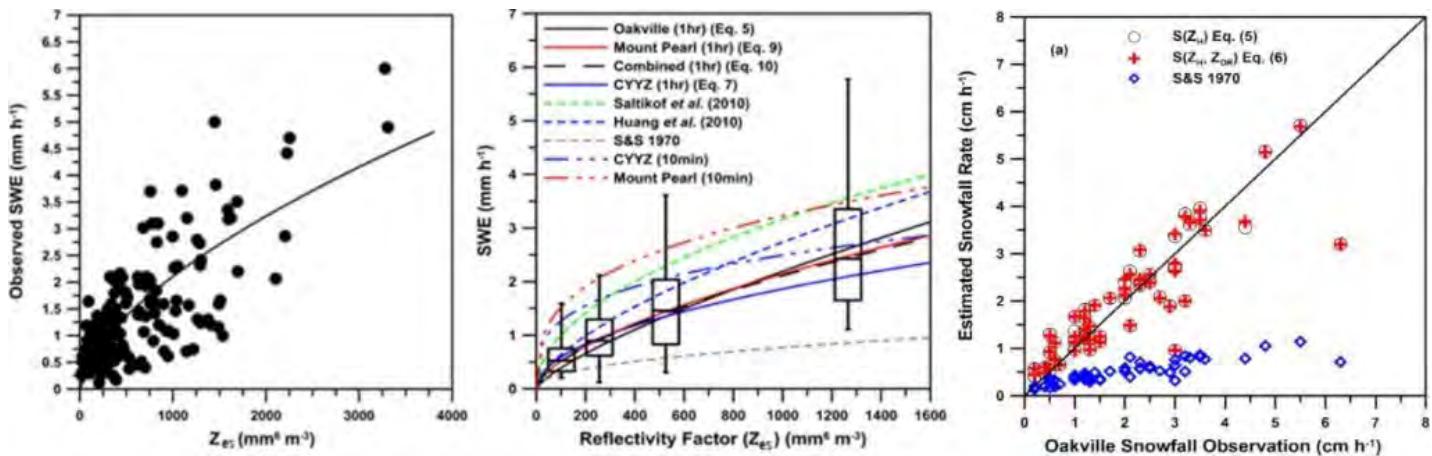
The radar reflectivity factor, Z, is “the sum of the sixth-powers of the diameters of the water drops in a unit volume of space, or the melted diameters of the snow and ice particles in a unit volume”. It is normally expressed in units of mm⁶m⁻³. It has a very wide range of values and its decibel value is dBZ = 10 log₁₀(Z/1.0 mm⁶m⁻³). Z is determined by the, generally unknown but assumed, size distribution of the precipitation. The strength of the backscattered radar signal depends on several factors such as radar parameters, physical constants, and path considerations but also on $|K|^2Z$, where $|K|^2$ is the dielectric constant of the hydrometeors causing the backscatter (see Fabry, 2015 for details). Even with rain, there are complications depending on the size and shape of the raindrops (e.g. are they Rayleigh scatterers). The $|K|^2$ factor is different between liquid water ($|K_w|^2 = 0.93$) and ice ($|K_i|^2 = 0.176$), and snowflakes are not simple spheres of ice. In processing radar backscattered power, the standard procedure is to calculate the value of $|K|^2Z$ that would give that power, assuming properties of the radar beam are correctly known. If dealing with rain, we can use $K = K_w$ and get a good estimate of Z, but for snow and other

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Weather services around the world (e.g. NWS) use and report Z_e from their radars, regardless of the precipitation type. On ECCC's public radar sites, however, in winter the displayed reflectivity, denoted hereafter as Z_{es} , is equivalent to $Z_e + 6.5 \text{ dBZ}$ after assuming that the snowflake backscatter is equivalent to that of ice spheres of the same mass. Figure 2 depicts an example of the ECCC public radar displaying Z_{es} . This can be based on the Smith (1984) analysis leading to $Z_{es} = Z_e/0.224$ or in decibels $Z_{es} = Z_e + 6.5 \text{ dB}$. The use of Z_{es} appears to be unique to ECCC and, as we see it, is a potential cause of confusion. It would be better to just use Z_e .

Snowfall Rates

For snowfall, ECCC use a relationship based on the melted diameter distributions from Gunn and Marshall (1958) and Sekhon and Srivastava (1970); $Z = Z_{es} = 1780 R^{2.23}$ and $R = 0.0338 Z_{es}^{0.4525}$, where R is the SWE precipitation rate in mm h^{-1} . Hassan et al. (2017) compared sets of measured SWE during solid snowfall events in the Toronto and St John's areas to establish alternative $R(Z_{es})$ relationships. Their overall best fit is $R = 0.0295 Z_{es}^{0.618}$, based on precipitation rates computed from 10 min radar reflectivity values, Z_{es} , provided by ECCC (raw radar data), added and compared to in-situ hourly (and sometimes other) SWE measurements. Although there is considerable scatter in the data, seen in Figure 3, the relationship indicates much higher snowfall rates than the Sekhon-Srivastava (S&S) relationship employed by ECCC. This can also be seen in Figure 4, where the current ECCC relationship is severely underestimating snowfall rates. The Finnish Meteorological Institute (FMI) equation is also shown (converted here from Z_e to use Z_{es}) in addition to the Huang et al. (2010) equation. Several relationships based on subsets (Oakville, Mt Pearl, etc.) of the Hassan et al. (2017) data are also shown in this figure.



(Left) Figure 3. SWE(Z_{es}) fitted using the combined hourly data from Oakville, CYYZ and Mount Pearl. (Hassan et al., 2017). (Centre) Figure 4. Snow water equivalent (SWE) estimation versus reflectivity factor (Z_{es}) using 1 h interval data, the combined dataset, 10 min interval data, Saltikoff et al. (2010), Huang et al. (2010) and the Sekhon and Srivastava (1970) algorithms. The box plots represent 25, 50 and 75% of the observed data while the whiskers represent the extremes. From Hassan et al. (2017). (Right) Figure 5. Estimated snowfall rate (cm h^{-1} , from Hassan et al. (2018) relationships, $S(Z_{hi})$ and $S(Z_{hi}, Z_{DR})$ and from the ECCC operational algorithm based on Sekhon and Srivastava (1970) versus observed snowfall rates at Oakville, ON for Jan-Mar 2011, Jan-Feb 2012, Dec 2012 and Jan-Feb 2013.

Snow depth measurements and snow-to-liquid equivalent ratio (SLR) measurements are less generally available nowadays due to the conversion of most of the manned reporting stations to use automated weather observing systems (AWOS). However, Hassan et al. (2018) collected data, manually, in Oakville, over 2 winter seasons, and derived the $S(Z_{es})$ relationship, $S(\text{cm h}^{-1}) = 0.057 Z_{es}^{0.59}$, referred to as Eq. (5) in Figure 5. This figure includes a comparison of that relationship versus the observations, together with the S&S estimations using $\text{SLR} = 10$, and also Eq. (6) from Hassan et al. (2018), derived from dual-polarization data. Further studies along these lines would be useful and if solid snowfall rate ($S \text{ cm h}^{-1}$) is required then a direct $S(Z_e)$ relationship rather than from $SWE(Z_{es})$ and SLR would be desirable.

Radar estimation of solid snowfall rates is of great importance to meteorologists and winter maintenance crews as they both rely on such parameters when issuing warnings and mobilizing snow removal or treatment crews to affected areas. The application can also be extended to hydrological applications and $Z(S)$ relationships for radar data assimilation into numerical weather prediction (NWP) models.

The popular smartphone application, WeatherCAN, merges US and Canadian radar data, but many members of the Canadian public access ECCC radar data as imagery through the radar and historical public web sites. These services are very useful, but for many with a deeper interest or concerns about the weather, it would be appreciated to have

Article: A Note on ECCC Radar Snowfall Estimates

more imagery (Doppler and dual-polarization) and easy access to gridded values of radar variables and other numerical data (e.g. NWP). Canadian data are also used by providers of blended US and Canadian radar data including the Weather Network and the Weather Underground. Those suppliers pay ECCC for delivery of real-time numerical data.

In contrast, many, if not all, of such products and data are freely available from the US National Weather Service radars (NEXRAD). For example, Doppler images (Velocity) and archived (up to the previous day's data) images and digital information are accessible to the public.

While European countries are making their radar data increasingly openly available, there remains a well-positioned economic interest group in ECOMET that coordinates most countries' mandated cost-recovery policies regarding data and products. Despite excellent availability of EUMETNET OPERA reflectivity composite imagery access to the underlying product data and original polar scan and volume data sets, outlined in Huuskonen et al. (2014), continues to be challenging with different procedures and technical solutions depending on data and user type.

The Australian Bureau of Meteorology has an interesting solution, where they push data to an FTP service and charge a cost-recovery fee for access to it. Authorized users then pull data from this service. Data is also freely available on an academic network shared by universities. These solutions are preferable to actively pushing data to individual clients.

Summary

- ECCC should switch to display equivalent radar reflectivity factor (Z_e) rather than Z_{es} .
- ECCC should encourage radar snowfall studies, internally as well as in academia and the private sector, to improve estimates of precipitation from radar given its many applications.
- ECCC should provide public access to more imagery (Doppler and dual-polarization, both current and archived) and reasonable access to full scan radar parameters for universities, other researchers and private companies. There is also a need for metadata including calibration documents.

Acknowledgements

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About the Authors

Diar Hassan: Diar is a Senior Scientist, Product and Business Development and an Accredited Consultant Meteorologist and Environmental Professional with nearly 20 years of experience. He has served as a consultant meteorologist for an array of clients in different sectors and successful projects. His broad scientific and business development background have proven fruitful in developing new services and products using cost-effective technologies. He has led several projects that encompassed climatological, meteorological, and environmental effects on client operations and logistics.



George A. Isaac: George retired in 2013 as a Senior Scientist from ECCC after 40+ years of service. He formed a small company Weather Impacts Consulting and has continued doing research. He is also active as an Adjunct Professor at York University and Dalhousie University with their Atmospheric Science groups. Current projects include studying winter weather, aircraft in-flight icing, better methods for using weather radar data, and improving forecasts of high impact weather offshore Newfoundland and Labrador.



Peter Taylor: Peter has been a Professor of Atmospheric Science at York University since 1988, when he moved there from the Boundary-Layer Research division of Environment Canada. Most of his research has involved atmospheric boundary-layer flows in complex terrain but his current research has broadened to include fog, precipitation, and radar issues. He is quickly learning how complex things become when water vapor condenses or freezes.



Daniel Michelson: Daniel leads ECCC's weather radar research program in the Meteorological Research Division. He began working at ECCC in 2015 after 21 years at the Swedish Meteorological and Hydrological Institute. He chairs the WMO Inter-Programme Expert Team in Operational Weather Radars, which includes addressing availability and international exchange of weather radar data. He is also an advocate for Open Science, teaching Open Source radar processing software courses normally held in conjunction with major radar conferences.



Norman Donaldson: Norman has been a radar research scientist at Environment and Climate Change Canada since 1990. He holds math and physics degrees from the University of New Brunswick, Western University and the University of Toronto. His primary interest is in processing radar data and assessing its quality, with the goal of providing usable data to research and operational users. He has contributed to numerous field programs and is actively involved in the scientific direction of ECCC's radar processing systems.

CMOS Statement on Racism: A Time to Act

We witness with anguish the violent and fatal results of endemic anti-Black racism within the institutions of law enforcement in the United States, Canada, and worldwide. The subsequent tributes to George Floyd, and protests against police brutality and racism in both the USA and Canada have elevated the issue to the forefront of public attention, and remind us of the systemic injustices faced by Black communities.

The Council of the Canadian Meteorological and Oceanographic Society (CMOS) believes it is our profound responsibility to stand with our colleagues across many scientific societies, including the [Canadian Association of Physicists](#), the [Chemical Institute of Canada](#), the [American Geophysical Union](#), and the [American Meteorological Society](#) in affirming our support for equity, inclusion, and diversity. We are all diminished when a person believes that our endeavours do not have room for someone of their ethnic background or skin colour. However, it is important to go beyond this, and to speak out about Canada's own history and perpetration of systemic racism against Black, Indigenous, and other racialized people and communities. We must consider the impact of racial discrimination (e.g., against Asian Canadians as a result of the COVID-19 crisis), conscious and unconscious bias, and systematic barriers to professional success experienced by Black, Indigenous, and other racialized people in the CMOS context. And we must combat this racism, in the context of our research and professional practice, and in partnership with Tri-Council agencies. We must also acknowledge that CMOS has done little in its past activities to address these issues, and has much to do to catch up to our colleagues in partner societies.

There are many ways in which our specific work in atmosphere, ocean, and climate science can be directed towards addressing systematic racism within Canadian society. For example, the effects of severe weather events and destructive climate change are systematically exacerbated by social inequality, including inequality associated with racism (e.g., [Nazrul Islam and Winkel 2017](#)). In this and other areas, it falls squarely within CMOS's responsibility to highlight such differential impacts that might be experienced by racialized peoples, and engage in informing policy makers and the public about this. These and many other examples can be drawn from our professional practice and should be a focus in the coming years.

We encourage all CMOS members to consider these issues, to condemn racism, to support members of Black, Indigenous and racialized communities, and to work to create an equitable culture, both within CMOS and in Canadian society.

Kimberly Strong, CMOS President
Marek Stastna, CMOS Vice-President
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You can also find this statement on the www.cmos.ca website at the following link:

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CMOS News

CMOS Recognizes 2020 Awards Winners

OTTAWA, June 12, 2020/ As part of its Alternative Congress and leading up to its Annual General Meeting (AGM), the Canadian Meteorological and Oceanographic Society (CMOS.ca) is pleased to announce that ten Canadian scientists, scholars, and researchers have been recognized for their outstanding achievements in advancing knowledge and understanding in the fields of atmospheric sciences, hydrology, meteorology and oceanography. This continues a long tradition which started 53 years ago when the Society was founded. Recipients were recognized for their work in advancing weather prediction capabilities, supporting Olympic weather forecasting, understanding the role of biology in ocean dynamics, training and mentoring students, and publishing major research works.

This year's AGM on June 23rd signals the end of CMOS's alternative, virtual Congress that has been taking place over the past few weeks in lieu of its traditional Congress. CMOS is proud to celebrate the accomplishments of its winners, as well as the important work of its CMOS members who have convened a total of 16 virtual sessions on topics relating to this year's Congress theme: "Building Societal Resilience to Changing Weather, Climate, Oceans and Environment."

"We are delighted to recognize this year's recipients of three CMOS prizes, two medals, one award, and one fellowship for their important contributions and accomplishments in meteorology and oceanography. At the same time, CMOS announced the winners of its undergraduate and post-graduate scholarships." says CMOS President Kimberly Strong.

To view a complete list of 2020 winners and their citations, please click [here](#).

CMOS is a major non-governmental organization serving the interests of meteorologists, climatologists, oceanographers, limnologists, hydrologists, and cryospheric scientists in Canada. The Society addresses a broad range of national and international meteorological and oceanographic concerns including weather and weather extremes, global warming, ozone depletion and surface air quality and their effects on all aspects of life in Canada including forestry, agriculture and fisheries.



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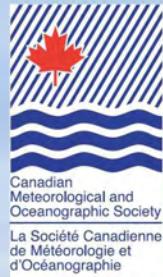
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Après 45 années de publication papier, le Bulletin de la Société canadienne de météorologie et d'océanographie (SCMO) passe en mode virtuel. Consultez le site bulletin.scmo.ca pour lire des articles, des nouvelles, des annonces d'événements et des faits nouveaux que partagent les éminents météorologues, climatologues et océanographes du Canada.

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NEW Books Available for Review

Winds, Waves and Warriors: Battling the Surf at Normandy, Tarawa, Inchon, 2019. By Thomas M. Mitchell, Louisiana State University Press. ISBN 978-0-8-71-7223-0 (Cloth), 168 pages, \$39.95 USD (2020-1)

Waters of the World: The Story of the Scientists Who Unraveled the Mysteries of Our Oceans, Atmosphere, and Ice Sheets and Made the Planet Whole, 2019.

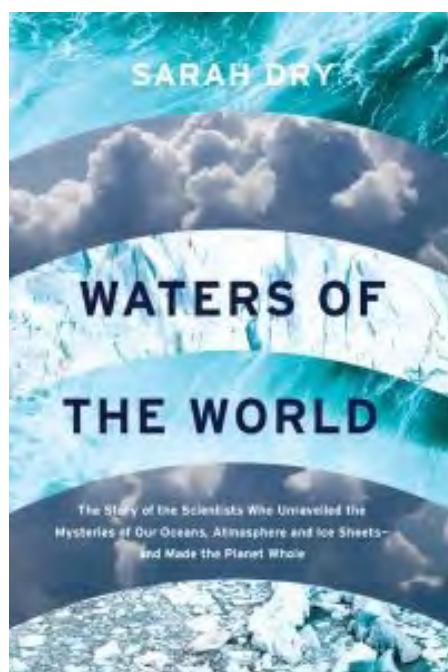
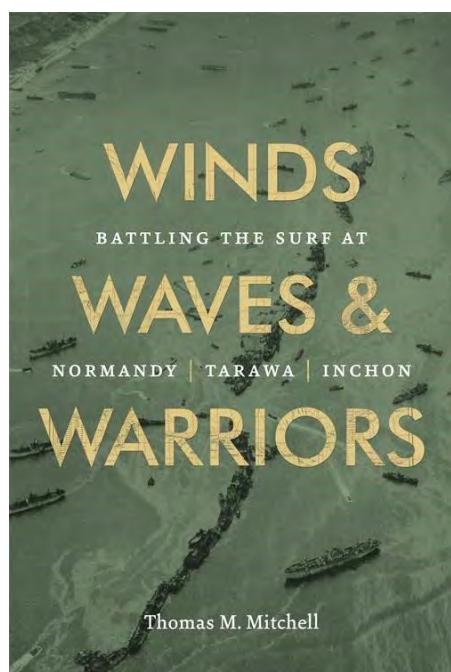
By Sarah Dry, University of Chicago Press. ISBN 978-0-226-50770-5 (Cloth), 368 pages, \$30.00 USD (2019-4)

Other recent titles still available for review by a CMOS member:

- **An Introduction to Tides**, 2019. By Theo Gerkema, Cambridge University Press, ISBN 978-1-108-46405-5 (Paperback), 211 pages, \$51.95 USD (2019-3)
- **A Bright Future: How Some Countries Have Solved Climate Change and the Rest Can Follow**, 2019. By Joshua S. Goldstein and Staffan A. Qvist, Hachette Book Group, ISBNs 978-1-5417-2410-5 (hardcover), 978-1-5417-2409-9 (e-book), 288 pages, \$34.00. (2018-9)
- **Tropical Extremes: Natural Variabilities and Trends**, 2019. Edited by V. Venugopal, Jai Sukhatme, Raghu Murtugudde, Remy Roca, Elsevier Inc. ISBN 978-0-12-809248-4, 333 pages, US\$110 (2018-11)
- **World Seas, An Environmental Evaluation. VOLUME III: Ecological Issues and Environmental Impacts**, Second Edition, 2019. Edited by Charles Sheppard, Elsevier Inc. ISBN 978-0-12-805052-1, 633 pages, US\$250. (2018-12)
- **Rainbows: Nature and Culture**, 2018. By Daniel MacCannell, The University of Chicago Press and Reaktion Books Ltd, ISBN 9781780239200, 208 pages, US\$24.95 (2018-4)
- **The Deep Pull: A Major Advance in the Science of Ocean Tides**, 2018. By Walter Hayduk, FriesenPress, ISBN 9781525518706 (hardcover) \$35.49, 9781525518713 (softcover) \$27.49, 9781525517820 (eBook) \$11.99, 251 pages. (2018-7)

Never reviewed a book before? No problem! Check out some of these past reviews for ideas: [Ice: Nature and Culture](#); [Weather in the Courtroom](#); [Convenient Mistruths: A Novel of Intrigue, Danger and Global Warming](#); [Weather, A Very Short Introduction](#); [Nonlinear and Stochastic Climate Dynamics](#).

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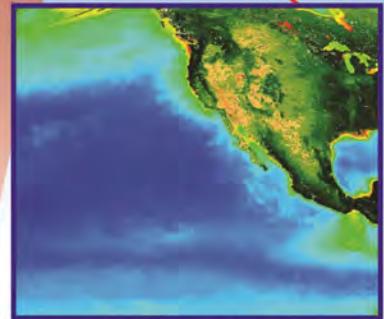
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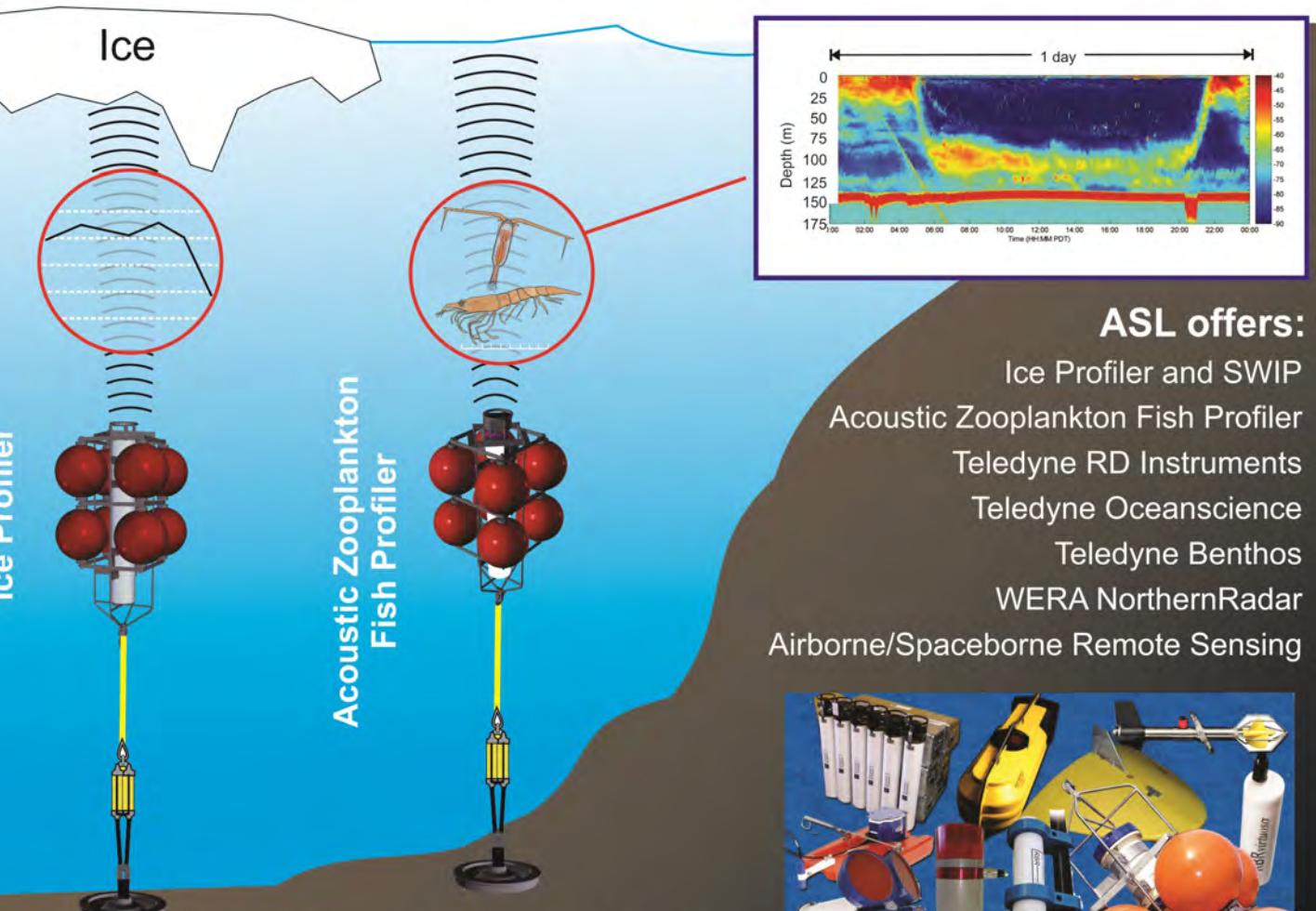
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Thank you to Bob Jones for his continued editorial assistance and guidance.

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